Enhancing the Quality of U.S. Grain for International Trade

Volume II -- Background Papers

Part C: Economics and Institutional Factors of Grain Quality

1. Analysis of Demand for Wheat Quality Characteristics
2. Farm Programs and Grain Quality
3. Effect of Domestic Regulatory Policies on U.S. Grain Technology and Quality
4. Analysis of United States Grain Standards

August 1989

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Enhancing the Quality of U.S. Grain for International Trade

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Part C: Economic and Institutional Factors of Grain Quality

Paper No.

1. Analysis of Demand for Wheat Quality Characteristics by William W. Wilson, Jean Riepe, and Paul Gallagher
2. Farm Programs and Grain Quality by William W. Wilson, Craig Anderson, and Paul Gallagher
3. Effect of Domestic Regulatory Policies on U.S. Grain Technology and Quality by Rhond Rudolph Roth
4. Analysis of the United States Grain Standards by Lowell D. Hill

Background Paper No. 1

Analysis of Demand for Wheat Quality Characteristics

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I. Introduction

There are many different classes of wheat produced and traded in the world grain market. Differences between classes are due to either indigenous or extraneous characteristics. Color, protein level and quality, strength, and hardness are all indigenous characteristics. Extraneous characteristics include grade factors and nonmillable material or impurities. The quality of wheat which is produced and exported has the potential to be an important competitive factor in international trade. Indeed, as the intensity of competition in wheat trade has increased so has the differentiation of important quality characteristics. These differences vary by exporter country and result from the cumulative effects of tradition in agronomic practices, climate, breeding and variety release programs, regulations, and trading practices. Due to the fact that the forces influencing these differences are very institutionally entrenched, changes in indigenous or extraneous characteristics of export wheat quality are very slow to evolve.

Of particular importance to exporter competition is the influence of quality on the demand for different characteristics. Many factors influence the demand for quality characteristics. Relative prices, income, preferences, milling and baking technologies, and domestic production all potentially influence the demand for quality characteristics. Preferences are related to wheat products consumed and as incomes increase, or the mix of importers change, shifts may occur in the demand for characteristics. Income levels have an impact on the ability to pay and/or influence preferences. The level of domestic production in importing countries may influence the quality requirements of imported wheats, i.e., increases in domestic production may shift requirements from filler wheats to blending wheats. Some markets are highly price conscious, others may be more quality conscious. The latter implies limited substitutability in response to changes in relative price levels. A market may be quality conscious in this context and still be an importer of relatively cheap or expensive wheat classes. In the former case, major changes in relative price levels (i.e., decreases in the higher priced wheats) would be necessary to induce a change in import shares.

The overall purpose of this study is to analyze selected markets for changes in demands for wheat characteristics. There are two specific objectives. The first is to identify the extent of responsiveness of import market shares to relative prices, income, preferences, domestic production, and other factors. The second is to analyze preferences for wheat by class and to estimate changes in these preferences. This report is organized in four major sections. Background information and a review of related studies is provided in Section II. There have been several previous studies on the demand for wheat quality characteristics, as well as several recent analyses on exporter competition. Each of these are reviewed in this section. Section III provides a description of the behavior of relative wheat prices in international trade. Implicit values of specific wheat quality characteristics are estimated and presented in this section. The results of a cross-sectional analysis on the factors which influence wheat class market shares are presented in Section IV. The thrust of the empirical analysis presented in this report is a time series analysis of demand for wheat by class. Results for selected developing regions, as well as the United States, Japan, and the World are presented in Section V. The dynamic influence of selected variables on wheat class market shares are analyzed, and preferences for characteristics are measured and discusses.

II. Background and Previous Studies

Competition in the international wheat market is intense and quality potentially plays an important role in price determination and trade flows. As a preface to subsequent empirical analyses, the purpose of this section is to provide a descriptive review of production and consumption in wheat and the competitive environment as it relates to wheat quality. The first three subsections provide a description of international wheat production, and consumption with particular attention to quality differences. The nature of international competition in wheat is described in the following subsection. There have been a number of studies recently on the demand for wheat in general, and the differentiated nature of demand for wheats of different quality characteristics. Each of these is reviewed in the final section.

Wheat Classification and Production

Wheats can be categorized according to kernel hardness, growing habit, and bran color. Protein level and protein type are highly correlated with hardness so that hard (medium-hard, soft) wheats are high (medium, low) in protein content and have the kind of proteins important to breadmaking quality. Whether a wheat is sown in the winter or spring identifies its habit. Wheats are also categorized by bran color, either red or white. Wheat types are usually referred to by linking together the descriptive classification system labels into such terms as hard red spring, soft red winter, or medium-hard white. Durum is usually not classified along with the common wheats as it is highly specialized for use in pasta products.

Various types of wheat are produced around the world based on conduciveness of the climate for cultivation of particular wheat types. For example, the semi-arid climate found around the Mediterranean Sea is particularly suitable for the production of durum wheat. Environmental factors including rainfall, temperatures, soils, available nutrients and topography influence and cause wide variety in wheat characteristics such as protein content, test weight, and kernel size. Genetics is also a major factor in wheat characteristics. Plant breeding programs differ greatly from one producing area to the next resulting in wide variations in inherited attributes. Differences in environment and genetics among wheat producing areas of the world or within a country result in wide variations in the characteristics of wheats produced, even among those of the same general type.

Classes of wheat, rather than being synonymous with types of wheat, are defined for the purposes of this study by official grading standards of exporting countries. Distinctions between wheats of the same type grown in different countries or areas of the same country are necessary for two reasons. One is that wheats of similar type do not possess identical characteristics. Classification by type may be too general to account for differences in demands for imported wheats. The second reason is that country of origin is thought to be one basis of differentiation in demands for wheats (Grennes, Johnson, and Thusby). Lumping together wheats of the same type from different countries would not allow examination of demand behavior related to origin.

Numerous classes of wheat are available from the major wheat exporting countries of Argentina, Australia, Canada, France, and the United States. The various classes are presented in Table 1 where they are categorized by type. Although each country exports more than one wheat class, the United States is alone in exporting five classes in significant amounts. Hard Red Winter (HRW) has always been the dominant class in U.S. wheat exports followed by Hard Red Spring (HRS), White (WHI), and Soft Red Winter (SRW) jockeying for the second through fourth positions. Durum (DUR) is consistently the class with the lowest export volume. The remaining exporter countries are each known for one dominant class, or in the case of France, type. Argentina predominately exports Trigo Pan (TP) while Canada has established a reputation with high breadmaking quality Canadian Western Red Spring (CWRS). France, a member of the European Community, exports soft wheats (EC). Australian Standard White (ASW) is by far the dominant class in Australian wheat exports.[1]

Uses and Characteristics of Wheat

Wheat is used for seed, livestock feed, industrial purposes, and human food. Food is the highly dominant use although feed use has increased in the past few years. Nearly all wheat for human use is milled into flour or granular products. Although suitability for breadmaking is the quality standard in the United States, wheat quality actually is relative based on suitability for a particular end use, not just white pan bread (Zeleny, p. 19). Physical criteria of wheat quality include test weight, kernel size and shape, kernel hardness, vitreousness, color, damage, and impurities. Chemical quality criteria include moisture content, protein content, protein quality, alpha-amylase activity, fat acidity, crude fiber, and ash (Zeleny, p. 22).

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[1] The acronyms in parentheses are used throughout the remainder of this report.

TABLE 1. EXPORT CLASSES OF WHEAT CATEGORIZED BY CHARACTERISTICS AND COUNTRY OF ORIGIN

Country/Wheat Class	Characteristics						
	Kernel Hardness			Bran Color		Habit	
	Hard	Med-Hard	Soft	Red	White	Winter	Spring
Argentina							
Trigo Pan	X			X		X	
Fideos and Candeal Taganrock (durum)[1]							
Australia							
Prime Hard	X				X	X	
Hard	X				X	X	
Australian Standard White		X			X	X	
Australian Standard White--Soft Varieties			X		X	X	
Australian Soft			X		X	X	
Durum[1]							
Canada							
Canadian Western Red Spring	X			X			X
Canadian Prairie Spring		X		X			X
Canadian Utility	X			X			X
Canadian Western Red Winter	X			X		X	
Eastern			X		X	X	
Western Amber Durum[1]							
France							
By Lot Specifications			X	X	X	X	X
United States							
Hard Red Spring	X			X			X
Hard Red Winter	X			X		X	
White Wheat					X	X	
Western White			X		X	X	
Western Club			X		X	X	
Soft Red Winter			X	X		X	
Durum[1]							

[1] Durum is a highly specialized wheat type generally not classified with other types.

SOURCE: Canada Grains Council, *Wheats of the World*, (Winnipeg: Canada Grains Council, 1979), p. 25.

Protein, both by amount and kind, is the most important attribute of wheat in determining end use suitability (Zeleny p. 30). Protein quality, related to which amino acids are present and the arrangement of the many proteins, is basically an inherited characteristic [Canadian International Grains Institute (CIGI) p. 130]. Quality in protein is not easily defined nor measured. Protein content is also a function of genetics but is primarily affected by environmental factors. Protein quality is directly correlated to protein content so that the easier measurement of protein content also gives a reliable measurement of quality (CIGI, p. 431). Caution must be used in this generalization because it is possible for wheats of the same protein level to possess different baking characteristics (Zeleny, p. 31).

Required protein levels of typical American products and protein ranges for U.S. wheat classes are given in Table 2. The overlapping of class protein ranges portrays the possibilities of class substitution at favorable price relationships. Differences between protein ranges and realization of protein quality differences between classes reveal the inability of wheat classes to be perfectly substitutable or homogeneous from a technical perspective.

Durum is the most highly specialized type of wheat. While it can be used in the production of bread, couscous, bulgur, and fereek, durum is ideally suited to the production of semolina for pasta products. None of the common wheats possess the attributes of extreme hardness, tough endosperm, and amber color which result in pasta with cooking stability and preferred yellow color. Durum, therefore, normally commands a premium in the marketplace as do other hard wheats associated with protein level. However, durum does normally command a premium for its other unique and desirable attributes.

TABLE 2. REQUIRED PROTEIN LEVELS FOR WHEAT-BASED END PRODUCTS AND PROTEIN CONTENT OF U.S. WHEAT CLASSES

Uses		Sources	
Product	Protein Content	Wheat Class	Protein Content
	----percent----		percent
Pasta	13 and up	Hard Red Spring	12-18
Hearth bread	13-14	Durum	10-16
Hard rolls	13-14	Hard Red Winter	9-14
Pan bread	12-13	Soft Red Winter	8-11
Crackers	10-11	White Wheat	7-11
Biscuits	8.5-10.5		
Cake	9-9.5		
Pie crust	8-10		
Cookies	8-9		

SOURCES: Evans, S., Wheat: Background for 1985 Farm Legislation, USDA, ERS, Agriculture Information Bulletin Number 467, 1984, p. 3.

Zeleny, L., "Criteria of Wheat Quality," Ch. 2, Y. Pomeranz, ed., Wheat Chemistry and Technology, (St. Paul: American Association of Cereal Chemists, 1978), p. 30.

Product Consumption and Wheat Importation

Consumers generally prefer end products which make good use of the characteristics of wheat grown in their local or regional area (Agriculture Canada, p. 15). Tastes and preferences, then, tend to be regionalized by climate and culture (Agriculture Canada, p. 44). An example of this is in the Mediterranean area. Since durum wheat is grown there, products typically consumed in the region include bread, couscous, bulgur, and fereek, all of which are made from durum alone or in a blend with common wheat. The Far East provides another example of this behavior. Vast amounts of soft wheat are grown in this region so that in addition to rice, Chinese noodles, chappatis, and steamed breads are common consumer products.

TABLE 3. REGIONAL TASTES AND PREFERENCES FOR WHEAT-BASED END PRODUCTS AND THEIR REQUIREMENTS

Region	Major Products Consumed	Average Required Protein Level	Types of Wheat Used
Far East Asia	Pan Bread	12-14	Hard Red
	Steamed Products	10-11	Medium-hard
	Noodles	9-11.5	Medium-hard white
	Chappatis	9-10	Soft to medium-hard white
Middle East and North Africa	Bread		Durum, medium-hard white and red
	Couscous, Pasta, Bulgur, Fereek	9-11	Durum
Europe	White Pan Bread	10-12	Hard red, domestic soft
	Rolls	9.5	
	Pasta		Durum
Latin America	Breads	10-14	Hard red, domestic soft
	Pasta		Durum

SOURCES: Canada Grains Council, Wheats of the World, (Winnipeg: Canada Grains Council, 1979), p. 11.

Flour millers and other wheat product providers in importing countries are well aware of the tastes and preferences in their markets. Millers are interested in buying wheats which embody the characteristics suitable for the desired end products. The information in Table 3 provides a guide to regional tastes and preferences for end products as well as the required protein levels and wheat types to produce the end products. Western White Wheat has been the preferred U.S. wheat class imported by Far East Asian countries under PL-480 and the region still imports substantial amounts of white wheats from the

Liu, M., Personal interviews with Canadian Wheat Board personnel, 1983.

United States and Australia (Oleson, p. 21). Besides having appropriate protein content, white wheats are preferred because they produce products with acceptable color. The high protein breadmaking wheats are not well suited for many of the products, therefore the price premiums for hard wheats commanded in regions of high bread consumption would not be paid in the Far East (Oleson, p. 21).

Importers of wheat in regions of high bread consumption have more than one option for achieving protein levels required based on relative prices and qualities, government policies, and other factors (Oleson, p. 18). If there is sufficient domestic production of soft wheat, high quality wheats can be imported for blending to upgrade the flour. This is customary in the United Kingdom which imports CWRS and HRS for this purpose. In regions of insufficient or no local production, flour millers can either import moderately high quality wheat all of which is the desired protein content, or a combination of hard and soft wheats to blend together to achieve the required protein level. In the Mediterranean region, medium-hard white wheats from the United States and Australia are imported to fill the gap between domestic production and total wheat needs.

Market Organization

The organization of the international wheat market has not been constant over time because of ever changing supply and demand considerations. In the 1950s and early 1960s wheat demand was highly dispersed and focused on breadmaking quality wheat. Canada and the United States dominated exports. The North American exporters had considerable market power due to their market domination and willingness and ability to hold stocks (McCalla, p. 713). This was especially true for Canada which produced the vast majority of high quality wheat. A relatively stable pricing system developed in which Canada was the price leader, the United States the price follower, and fringe competitors pricing to sell their products (McCalla, p. 711; Oleson, pp. 93-101). Prices during this period were set more or less by administrative decision (Oleson, p. 91). Minimum acceptable market shares were obtained by both North American countries (Alaouze, Watson, and Sturgess, p. 173).

By the early to mid-1960s conditions had changed enough to provoke a major price war in 1965/66. Australia had increased production and storage capacity to the point where their exports influenced the world market. Both Australia and the United States had increased their production and exports of high protein wheats (Oleson, p. 117). The United States, dissatisfied with the pricing mechanism and an eroding market share, precipitated a price war in 1965 and another in 1968/69 (Oleson, p. 111). The export side of the market became more competitive although collusion among the then three dominant exporters has been suggested (Alaouze, Sturgess, and Watson, p. 174).

The United States reduced its export subsidy program in 1972 bringing the "duopoly pricing" era to an end. Since that time world trade is characterized by competition at the firm level by a small number of private firms and state trading agencies (Oleson, p. 122). The United States plays a dominant role in price formation due to its large volume of production and exports. The high level of U.S. participation in world wheat trade makes the existence of open market operations in the country, and its policies regarding wheat, of importance in the world market. Exports from Canada and Australia are controlled by government sanctioned monopolies. Current policy in both countries is to price wheat to minimize carryover stocks (Wilson 1986). The EC moved from being a net wheat importer to a net exporter using ever larger subsidies for private firms to sell the surplus in the world market. Although Argentine exports are achieved through private trading firms, government policy on carryover stocks is similar to that of Canada and Australia.

Domestic and trade policies of importing and exporting countries alike are important to the structure of the international wheat industry and trade. Government policy sets the tone of domestic price formation, whether prices are determined competitively or bureaucratically. In the United States market price is determined competitively, but loan rates and target prices are set legislatively. Policy also decides the nature of the institutions involved in the exportation or importation of wheat. The United States has left the job of wheat trade to private firms, Canada and Australia have export monopolies and Argentina has tried both arrangements. Government policy can also influence trading patterns (Canada Grains Council 1979, p. 25). Japan has diversified sources of supply in order to achieve steady, uninterrupted supplies.

Previous Studies on Wheat Quality Demand

The majority of research on wheat trade and demand, by far, has been conducted under the assumption that wheat is a homogeneous commodity. While this assumption can be useful or necessary for many applications, it provides no information when analyzing the role of quality factors in demands for wheats. Several researchers have recognized the heterogeneity of wheat and demands for wheats. Contained in this section is a survey of the discussions and analyses of others in the area of quality and its role in wheat trade.

Grennes, Johnson, and Thursby, in their 1978 study, sought to explain the pattern of world wheat trade. Wheat, according to the authors, can be broadly classified according to growing habit, such as spring or winter wheat, or by kernel hardness such as soft or hard. Soft wheats, it was noted, are used for end products such as cakes, pastries, crackers, and cookies. Hard wheats are more suitable for the production of bread. Durum was described as an ultra-hard wheat which is basically grown as a specialty crop for the production of pasta products. The authors contended that both intra- and inter-country trade is likely to occur due to the fact that different types of wheat are more suitable for some end product uses than others. An example given for inter-country trade was that Western Europe, while a large wheat producer itself, imports hard wheats from North America because of the softness of indigenous wheats.

In the discussion of the appropriate type of model to use in analyzing the pattern of trade flows, the choice was indicated of a model that distinguishes goods by country of origin. This choice was made based on the observation that actual prices and trade patterns of wheat do in fact suggest that importers distinguish wheat by country of origin. A couple reasons were given for this phenomenon. One was that importers perceive quality differences across producing countries, that wheats grown in different countries do differ based on climatic and genetic variations, and that different types of wheat are not perfect substitutes for the production of particular end products. Another cause of differentiation among wheats by country or origin was stated to be due to national factors, mainly politically based.

Oleson in 1978 conducted a primarily descriptive study of the international wheat market in order to provide a comprehensive picture of the environment in which price formation in the world wheat market occurred through time. Oleson divided the time frame of study into three periods: Period 1 including 1953/63, Period 2 including 1964/71, and Period 3 including 1972/78. During Periods 1 and 2 bread was the primary end product produced from imported wheats. Western European and other developed countries dominated imports. Consequently, Olseon classified wheats according to their breadmaking quality:

1) blending: high protein,
2) filler: medium protein, and
3) soft: low protein.

The bread producing importing markets basically could take three different courses of action to produce a flour with the desired protein level, about 12 percent:

1) import blending quality wheat to blend with domestically produced soft wheats;
2) import blending quality wheat and import soft wheat to blend together; and
3) import a filler wheat with the desired protein level.

Many importing countries such as the United Kingdom were constrained to using a certain level of indigenous soft wheat in flour production so that option 1 was generally the most cost effective alternative.

By Period 3 the situation in the world market had changed substantially, according to Oleson. The high quality blending wheat markets such as Western Europe had diminished in importance. Concurrently, advances in milling and baking technology allowed flour millers to decrease their average flour protein level. New, important markets consisting of nonbread consuming populations had developed, especially in Asia. Demand in these markets had largely been met through concessional sales in earlier years but later came to be an important force in commercial trade. As these primarily developing countries consume mainly nonbread products, demand in world trade in Period 3 had shifted to filler, medium protein, and softer wheats. These wheat types are more suitable for the production of nonbread products than are the high protein wheats.

Oleson criticized the common usage among economists of the wheat homogeneity assumption in model building. A preoccupation by researchers of wheat trade with estimation technique rather than precise specification led to the erroneous use of the assumption according to Oleson. A conclusion of this study was that some of the most important elements in the world wheat market are in fact the relationships between different qualities of wheat.

Canada Grains Council in 1985 reported the results of a study in an economic context of wheat class market structures and grade structures for Canadian wheat. Discussions of what constitutes wheat quality and quality in the context of international trade were provided. Wheat quality, it was noted, depends upon the particular end use. Notable differences in physical and chemical attributes exist between different wheat classes. Quality in wheat is not well understood nor is it confined to a single property of wheats.

International wheat trade has been characterized by change. One result is that there has been no consistent indication by the market of ideal wheat quality. Major importers purchase a variety of wheat classes and grades. Many new importers have entered the market which require different characteristics from the quality bread wheats in high demand during the 1950s and 1960s. Changes in milling and baking technology have resulted in lower protein requirements. Increased sophistication in milling and baking technology has made knowledge of the specifications of wheat shipments more important. Generally, the authors noted that required average flour protein differs by country and end product produced. The patterns of utilization are based on factors such as state of economic development, state of milling and baking technology, tradition, type and amount of indigenous wheat, and type and amount of importable wheats, all of which are subject to change. This adds to the shifting in classes imported and quality characteristics desired. The authors stated that existing patterns of wheat class utilization imply a preference for nonbread-making quality wheats of medium protein level.

A large study was conducted for Agriculture Canada in the early 1980s to provide information on the question of what mix of qualities in wheat production and exports Canada should shift toward in the future. The question arose from the Canadian commitment to expansion of exports in the face of future market uncertainties. One factor was the growing concern that future world wheat market growth will be in medium quality wheats demanded by developing countries. These countries generally consume nonbread products produced from medium quality wheats and, consequently, a premium for high quality breadmaking wheat would not be paid. In developed Western countries, bread consumption should not show any significant increases. This situation combined with the adoption of new milling and baking technologies which allow for utilization of lower protein flour has the Canadians concerned about their future if emphasis in production remains on high breadmaking quality wheat. From a production perspective, Canada faces a severe yield constraint on its high quality wheat. The only alternatives for increasing production, then, are either an unlikely increase in acreage or a shift to lower quality, higher yielding wheat varieties.

The Agriculture Canada study was concerned only with the demand side of the question. Analysis was done with other wheat exporting countries taken into consideration since Canada is not the sole exporter in a position to capitalize on expansion of medium quality wheat exports. For purposes of study and estimation, all classes and grades of wheat available for export were grouped into four relatively homogeneous types based on major end use. Type 1 included all grades of Canadian Western Red Spring and U.S. Hard Red Spring Wheat, both high quality bread wheats. Type 2 was formed to represent the medium quality wheats and included No. 1 and 2 Canadian Utility wheats, all grades of U.S. Hard Red Winter, and all wheat exports from Argentina and Australia, with the exception of small amounts of durum. The third type was composed of soft wheats and included remaining Canadian wheat grades and classes, all grades of U.S. Soft Red Winter and White Wheat, and all French wheat. Type 4 was composed strictly of durum wheats from all exporters.

A critical assessment of the class groupings in the Agriculture Canada study would be helpful in understanding the current study. Multicollinearity among wheat prices has long frustrated the analysis of demand for wheat. One common method of coping with the problem is to assume all wheat to be homogeneous and thus be left with one price of wheat. The grouping of exporter defined wheat classes into general types is another method of dealing with multicollinearity problems while maintaining general distinctions between classes.

One point of argument concerning the groupings used is whether the groupings adequately reflect homogeneous groups related to end-use considerations. An _a priori_ assumption is made that these particular end-use groupings are realistic for all regions of the world. Color considerations, potentially important in Asian markets as well as others are not provided for. The small number of groupings, in any event, makes this assumption quite restrictive. The consideration of country of origin also is not provided for in this grouping arrangement, another potential problem. Other researchers such as Grennes et al. have conducted analysis with models which differentiated wheat by country of origin and found this type of distinction useful. Given the political nature of world wheat trade and by country differences in wheat quality, credit availability and other national factors, the _a priori_ decision inherent in these groupings to ignore country of origin as a possible significant factor in import demand behavior is questionnable.

Empirical analysis in the Agriculture Canada study includes both model estimation and simulation. A wheat model which generates excess supply for each type of wheat exported by each country was estimated for each major wheat exporter, except Canada, for the period roughly 1960 to 1980. Import demand behavior was modeled by region. Country aggregations into regions, like class groupings into wheat types, were based on end-use considerations. For each region a linear equation of total wheat import demand was estimated along with a system of wheat type expenditure share equations. The time frame of estimation was similar to that of the exporter models. A world region was also estimated.

The world import demand model, along with the exporter models, was used for simulation over the period 1978 to 1990. Several simulations were run each with a different quality mix of Canadian exports assumed. The alternative assumptions of Canadian export quality mix were evaluated according to annual and cumulative export earnings over the period of simulation. The results showed significant changes in world prices by type. Significant revenue differences for Canada under the alternative schemes also were revealed, with higher proportions of medium quality wheats yielding higher revenues. The conclusion was made that the estimated gains in export earnings for Canada by an increased emphasis on medium quality wheats were high enough to suggest that there would be significant revenue gains at the producer level as well.

Woodhams wrote, in 1986, a descriptive report on the probable path of the world wheat economy for the subsequent five years with forecasts for 1991. A few major points related to wheat consumption patterns were emphasized. In developing countries both total and per capita consumption are expected to continue rising, although at a slower rate. Population growth is purported to be the dominant factor in increasing consumption, although increases in income level and degree of urbanization play roles as well. Developed countries, the USSR and Eastern Europe are expected to continue experiencing consumption declines or steady consumption levels. In general, developing countries are responsible for an increasingly larger proportion of total consumption with a 49 percent share in 1986 and a forecasted share of 54 percent by 1991. The production balance is also shifting towards the developing countries. Their share is forecast to account for 43 percent of world wheat production by 1991, up from 34 percent in 1980.

The prospects for import trends were determined from the forecasts for consumption and production. With the exceptions of Africa and West Asia, developing countries are expected to import similar amounts or less through 1991. This situation is based on expectations that production growth will equal or exceed consumption growth. The other major trend is for Soviet purchases to decline in 1991 to half of the 1985 total. In the total picture, the import share of developing countries is expected to increase from 63 percent in 1985 to 75 percent in 1991, although total import volume is expected to decline.

Woodhams suggested that exporter competition will continue to be fierce due to the decline in world trade volume. Policies in the U.S. are expected to help it regain some market share. Shares of other exporters are expected to vary depending on the loyalty of traditional markets and on the ability of a country's wheat quality to meet customer requirements. Canada is perceived to be in a vulnerable position due to the emphasis in that country on high quality wheats, thereby restricting productivity gains.[2] Developing countries are characterized as more price conscious. Australia and Argentina both are in positions to be price competitive in these markets.

Penfold reported on a study titled "The Grain Market to 2000," in the April 1987 issue of World Grain. The outlook to the year 2000 was summarized as follows. First, total grain demand is forecast to decline through 1990 and turnaround is predicted by 1995. Second, the developed countries, mainly EC and Japan, which were the basis for growth and stable trade in the 1960s and 1970s will decline in relative importance to a forecast 28 percent of trade by the year 2000. Demand in the EC has been depressed and will continue to decline as a result of the Common Agricultural Policy. Japanese demand has stabilized and will show very small increases in the next few years.

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[2] More recently, however, Canada has licensed two "medium" quality semi-dwarf wheats that are eligible for the new "Canadian Prairie Spring" grades.

Third, grain demand by the USSR is forecast to decline until 1990 with subsequent renewed growth. Overall, centrally planned countries have become and will be more important in world trade than was the case previously. The large centrally planned presence in the world market causes instability because imports are due to such factors as underlying economic efficiencies and capricious, poor weather. Reductions in centrally planned imports will account for the major proportion of trade volume reductions for the next few years. Fourth, the area of greatest potential for increased grain demand has become the developing countries where increases in total demand due to high population growth and in per capita demand due to economic growth are expected. Problems translating these demand increases into increased imports exist in the near term due to debt servicing and financing constraints, and slow economic growth. After 1990 these problems should be alleviated. Developing country trade was forecasted to account for 52 percent of world trade by 1995.

Lastly, the changes in major market players are resulting and will continue to cause trade distortions and uncertainties. The entrance and growing importance of the EC as a grain exporter has caused distortions in the historical market share relationships among the major exporters. In the current and near term environment of weak demand, EC presence has exacerbated trade difficulties and helped push world prices even lower. Uncertainties in the world market are the result of the shifting of grain demand from developed, more predictable countries to the less stable political and economic environments of centrally planned and developing countries.

Summary

Several themes seem to be recurrent in the above review of studies, and, therefore, are summarized here. Some researchers have indicated that it is not wheat in general but various characteristics of certain wheats which are demanded. End-use considerations are important in wheat demand, and different countries consume different end-products. From a total wheat import perspective, developing countries are rapidly becoming the areas of growth in world wheat demand.[3] Related to this is the observation by several researchers that wheat product consumption patterns in developing countries differ from the leavened bread orientation of developed countries. The demand growth in nonbread consuming countries has switched the emphasis in world trade away from high breadmaking quality wheats toward lower priced, lower protein wheats. Technological changes and declining consumption in developed countries has also aided this shift.

III. International Wheat Price Behavior

Critical to the analysis and understanding of demand for wheats of different characteristics is the behavior of relative prices through time. Changes in relative prices directly influence changes in demand. This will be analyzed in Section V.

Many quality characteristics are of potential importance in assessing the value of a particular class of wheat. Examples of quality characteristics include protein content, kernel hardness, 1000 kernel weight, as well as grade factors such as moisture content and damage. Some characteristics can be objectively measured (e.g., protein content) and are important nongrade determinants of prices, while others are reflected in grading standards of each country. Yet other quality characteristics are unique to the production/marketing system of a particular country including nonmillable material, uniformity, protein quality, etc.

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[3] This has been reinforced in a recent study by the International Wheat Council and cited in Milling and Baking News, (Vol. 66, No. 46, July 12, 1988, p. 1).

The values of these characteristics are reflected implicitly in prices. Some values may vary through time due to changing market fundamentals, whereas others may stay relatively constant. The purposes of this section are to (1) describe the behavior of international wheat prices with particular attention to quality differentials, and (2) to analyze the impacts of selected characteristics on the behavior of relative prices. The hedonic price analysis methodology is used to estimate implicit values of selected characteristics.

Description of Relative Prices

One of the best available sources of price data is the International Wheat Council (IWC) which publishes annual average prices at particular locations over extended time periods. Both FOB (free on board) and CIF (cost, insurance, and freight) prices are available. Of particular importance in making comparisons is to restrict comparison-making to prices at the same location rather than across locations. Differences due to transfer costs are eliminated and more appropriate comparisons of quality differentials are possible.

Comparisons are made in this section between U.S. FOB prices at both the U.S. Gulf and Pacific, and CIF prices at both Rotterdam and Japan. In each case only prices for the classes/grades of wheat normally traded at these markets are used. Absolute and relative prices are presented in Appendix

Tables A1-A6. Relative prices in each case use the price of U.S. Hard Red Winter ordinary protein as the denominator. Figures 1-4 illustrate the behavior of relative prices at these markets through time.

In each market world prices have been increasing since the 1960s. Prices reached a peak in 1973/74, again in 1980/81, and since have been declining. The behavior of relative prices is particularly interesting. In the years 1973/74 and preceding, the price differentials between wheat classes were very small, with ratios of relative prices being very close to 1.0. This behavior likely reflected the global food shortage situation and resultant lack of distinction between different qualities of wheats.

Since 1973/74 there have been several distinct trends resulting in overall increases in the price differentials between wheats of different classes and origins. Of particular interest are the general increases in the prices of the stronger high protein wheats, i.e., DNS 14 percent and CWRS 13 percent, relative to HRW ordinary.[4] Comparable increases in relative prices occurred both at the U.S. Gulf and Japan. The price of DNS 14 percent increased from 100 percent of HRW ordinary in 1972/73 to 118 percent in 1985/86 at the U.S. Gulf. The price of HRW 13 percent increased to 108 percent over HRW ordinary by 1985. Though there had been variability in relative prices throughout the time period, there were no other significant trends.

There were several important relative price trends apparent in the international markets. In Rotterdam, CWRS increased to 130 percent of HRW ordinary in 1974/75 and 1975/76, and has decreased since. More recent comparisons are not possible due to the lack of trade in HRW ordinary at

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[4] DNS is Dark Northern Spring which is a subclass of U.S. HRS.

Rotterdam. In Japan the price ratios between these two wheats increased to 116 and 121 percent, respectively, in 1974/75 and 1975/76, and since have increased to 125 percent. A similar pattern occurred with U.S. DNS in both markets. In Rotterdam, however, the decrease in relative prices after 1974/75 was much greater for DNS than for CWRS. In Japan, the appreciation of DNS relative to HRW ordinary was much less than that of CWRS. Australian Prime Hard (13 percent) did not appreciate in relative terms compared to either CWRS or DNS. With the exception of 1972/73, U.S. SRW has had a long-term appreciation relative to HRW ordinary at Rotterdam.

As a prelude to the hedonic analysis an alternative measure of differentiation is provided. Greenway provides three general measures of product differentiation including advertising intensity, the Hufbauer Index, and hedonic models. The former is not applicable in the case of international wheat, however, the other two are. The Hufbauer index is defined as: $H = \sigma_i/M_i$ where σ_i and M_i are the standard-deviation mean in prices calculated across wheat types. H was calculated at different points of time at several markets, FOB Gulf, CIF Japan, and CIF Rotterdam. Different time periods were used to demonstrate the change through time, and to accommodate for missing values (any missing price data would severely restrict the deviation of H). Results are shown in Table 4.

The results suggest that in general the degree of differentiation is similar at each of the markets. Also, of particular importance is that the degree of differentiation has increased substantially between the early 1970s and 1980s.

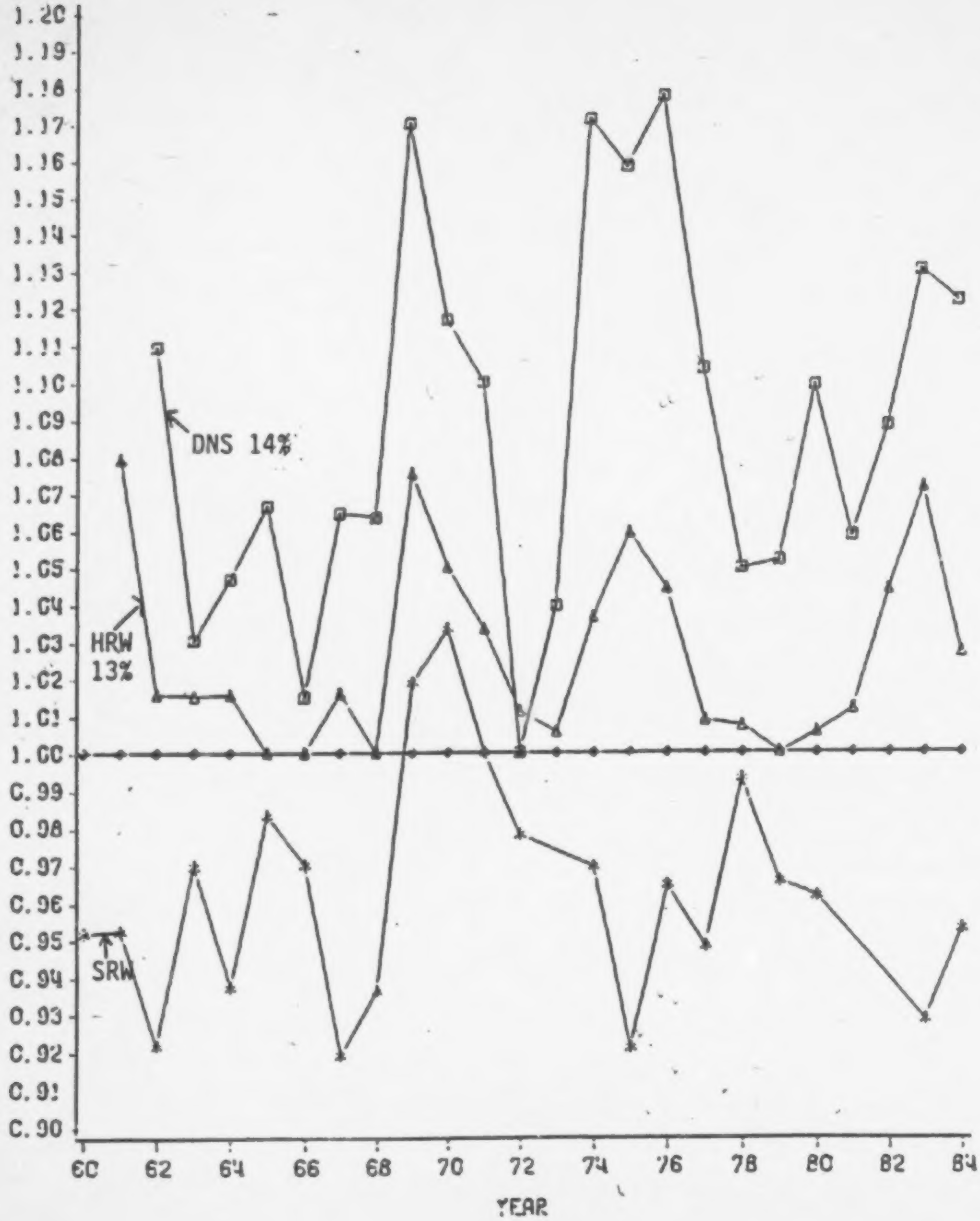

Figure 1. Export Prices Relative to HRW Ordinary, U.S. Gulf, 1960/61-1985/86

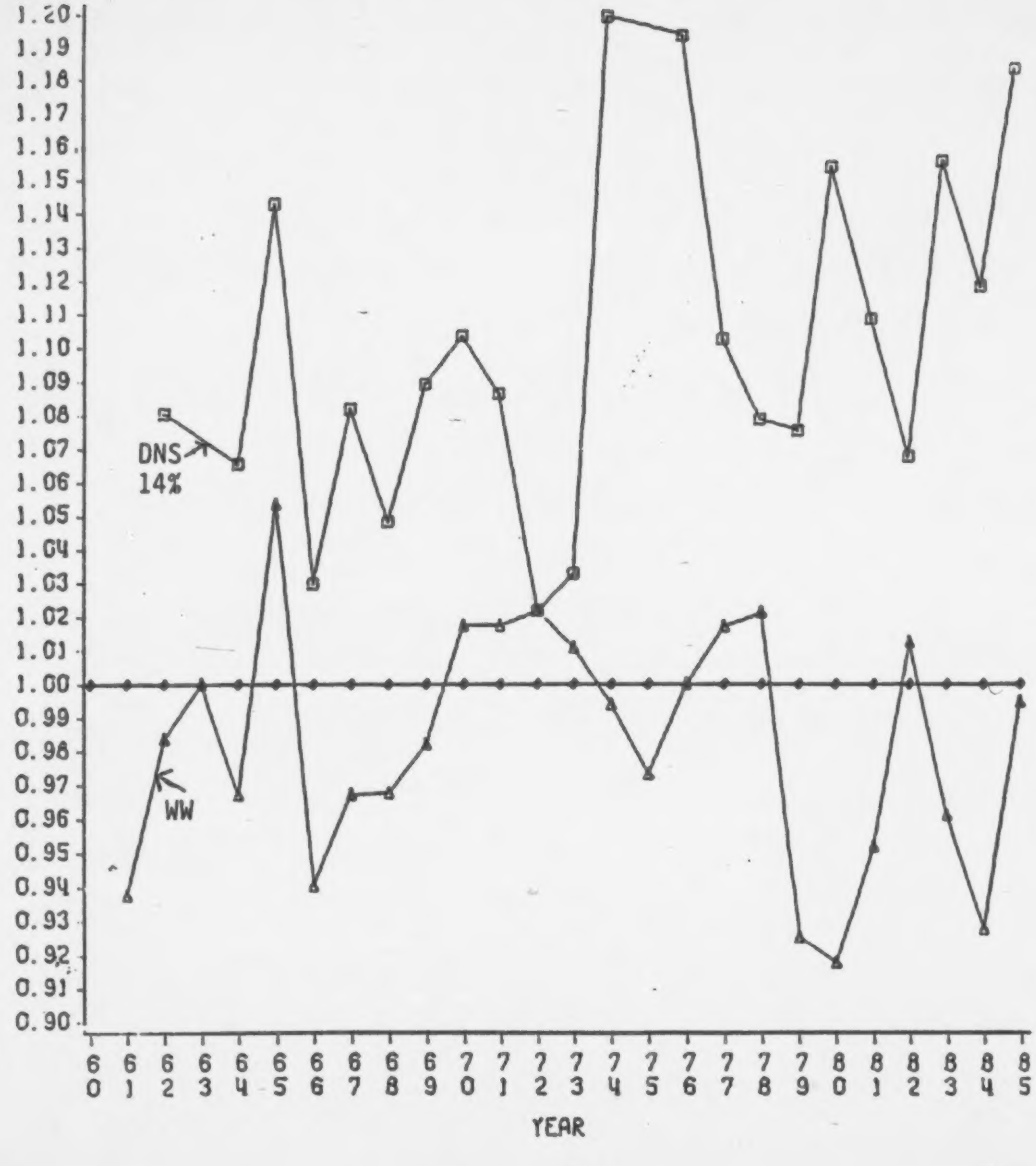

Figure 2. Export Prices Relative to HRW Ordinary, Pacific, 1960/61-1985

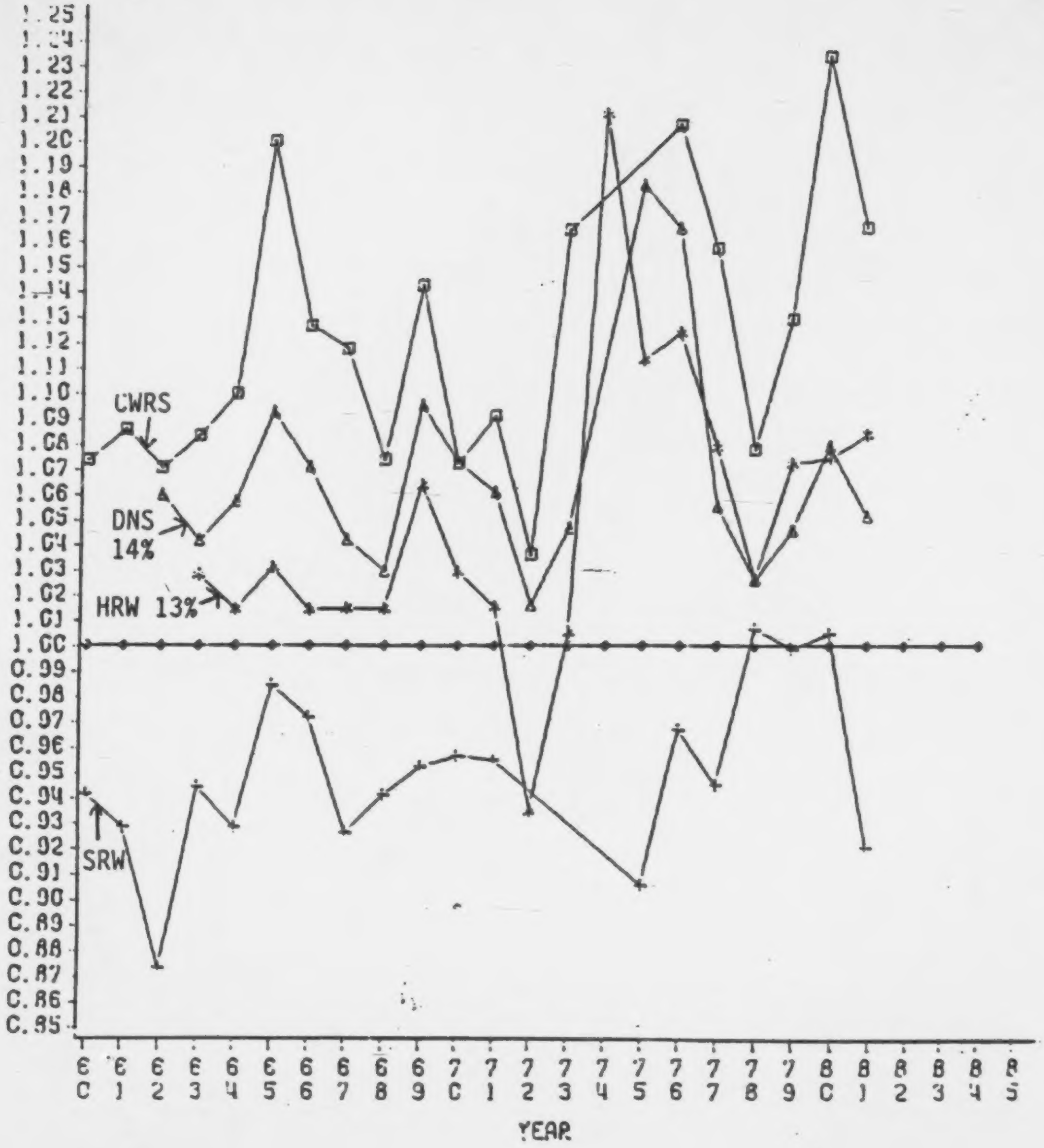

Figure 3. Import Prices Relative to HRW Ordinary, Rotterdam, 1960/61-1985/86

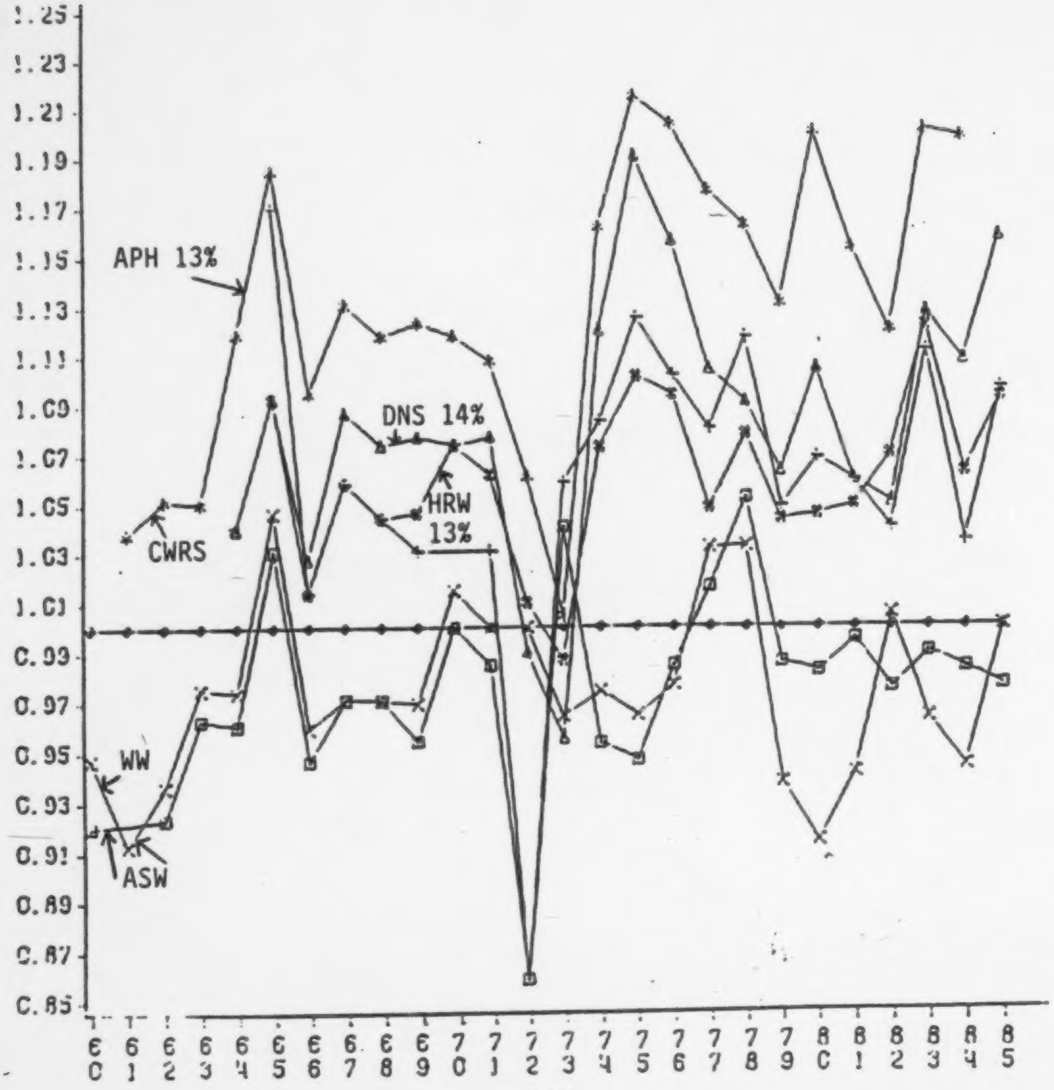

Figure 4. Import Prices Relative to HRW Ordinary, Japan, 1960/61-1985/86

✱ CWRS	△ DNS 14%
× WW	# HRW 13%
□ ASW	+ APH 13%

TABLE 4. HUFBAUER INDEXES IN THE INTERNATIONAL WHEAT MARKET

	1970/71	1972/73	1981/82	1985/86
FOB Gulf	.04	--	--	.09
CIF Rotterdam	.04	--	.08	--
CIF Japan	--	.03	--	.08

Analysis of Implicit Values

Imbedded in the prices discussed above are implicit values of particular quality characteristics. Differences in prices may be attributable to protein level, spring versus winter, and color. In addition, prices may vary due to country of origin reflecting the cumulative effects of a country's entire production/marketing system including the grading system, breeding programs, shipment reliability, cargo consistency, and credit availability. One way in which to detect implicit values of characteristics in prices is the empirical application of hedonic price analysis which is based on consumer behavior or the theory of the firm and the demand for inputs.

The logic of hedonic price models is that productive inputs, such as different classes of wheat, are demanded because of the particular characteristics they embody. The quantity of each quality characteristic is an argument for the production or utility function. Through mathematical derivation the implicit values of these characteristics can be derived and estimated. The methodology, very similar to that used here, was used previously in the analysis of malting barley prices as presented in Wilson.

In addition, there are numerous references to empirical application of hedonic price analysis as reported by Wilson.

The general empirical specification results in a functional relationship between prices and quality characteristics. In a two-characteristic good, for example, the model would be:

$$P_i = \alpha + \beta_1 C_{i1} + \beta_2 C_{i2}$$

where P_i is price and C_{i1} and C_{i2} are measures of two quality characteristics. Of particular importance and interest is the interpretation of the β_i's. Rigorously interpreted each is the marginal implicit value of a particular characteristic. As such, each reflects the value implied in the price of a unit increase in that characteristic.

In the case of international wheat prices there are two groups of variables. The first group varies within and/or between countries. Variables included are protein, which is a continuous variable, and hardness and growth habit (spring/winter) which are noncontinuous or binary variables. Variables in the second group are constant through time within a country or class. These include color and grade factors such as impurities, test weight, moisture, etc., all of which are constant. This second group of variables, due to their constancy are reflected by binary variables. The estimated coefficient associated with each variable provides a test of hypothesis as to whether that variable has a significant impact on prices. The value of the coefficient also provides an estimate of the implicit marginal value associated with that characteristic.

The specific model presented here incorporates several features to accommodate the data used. First, the data were pooled so as to consist of both time series and cross-sectional data across classes and countries. To account for the temporal variability in prices the IWC wheat price indicator was included in the model. Since this variable has only been calculated since 1972, the model was estimated for the post 1971 period only. Second, the growth habit category spring is highly related to hardness in some cases. For example, all spring planted wheats are hard, whereas some winter wheats are soft. To avoid potential multicollinearity, models were estimated and presented including both categories individually as well as combined. Third, from a demand perspective protein generally only has implicit value for hard wheats. Since soft wheats are normally not purchased for protein level (although in some cases lower protein is desirable), the implicit value of protein was constrained to hard wheats. Additionally, review of wheat prices by protein level in U.S. domestic markets suggests that the implicit value of protein varies through time (Wilson, Gallagher, and Anderson). To allow for this variation, a protein variable for each year was included in combination with a binary variable identifying an individual year.

Separate models were estimated for two export locations in the U.S. and two intentional destinations. This precludes implicit differences associated with location which would vary through time in response to relative ocean rates. Classes used in each model are those shown in Tables A1-A3 for each respective market. The general model for estimation is:

$$P_{it} = \gamma_0 + \gamma_1 \, IWC_t + \delta_1 \, Spring_{it} + \delta_2 \, Country_{it} + \delta_3 Hard_{it} + \sum_{YR = 73}^{85} \beta_{YR} \, (PRO_{it} \cdot Hard_{it}) + U_{it}$$

Variables are defined as: P_{it} is the price of wheat from origin/class i in time t; IWC_t is the International Wheat Price Index; $Spring_{it}$ is 1 if Spring and 0 otherwise; Country_{it} (used only in models at international destinations) in the case of Rotterdam is 0 if U.S. origin, 1 if Canada origin. Two country variables were included in the case of Japan with the default value being Australia; hard_{it} is 0 if the wheat is soft and 1 if hard; PRO_{it} is the protein level of the i^{th} wheat; and U_{it} is a random error term.

The estimated parameters $\delta 1$ and δ_2 represent the marginal implict value (or implied premiums or discounts) associated with Spring and country, respectively. The implicit value of protein level is allowed to vary by year, as represented by β_{YR} (YR = 73, . . . 85), and applies only to hard wheats. Similarly the implicit value of hardness depends on the protein level and varies by year. Formally, the implicit value of hardness is $\frac{\partial P_{it}}{\partial \text{Hard}_{it}} = \delta_3 + \beta_{YR} \cdot \text{PRO}_{it}$. In each case the intercept term is reflective of soft wheats.

In temporal hedonic price analysis it is very important to use price data from one consistent source to preclude introduction of differences due to measurement. It is also necessary to use price data for specific locations to eliminate differences which would be implied due to relative transport cost if using different locations. For these reasons the price data used in this study were taken from various issues of World Wheat Statistics (International Wheat Council). Separate models were estimated for two FOB export locations in the U.S., FOB Gulf and FOB Pacific, and two international destinations, CIF Rotterdam and CIF Japan. Separate models were estimated for each market from 1972/73 to 1985/86 market years (beginning July of each year).

The wheat prices used in the hedonic price analysis are shown in Tables A1-A3. Information on quality was taken from Wheats of the World (Canada

Grain Council), Canadian International Grain Institute, and unpublished data from the International Wheat Council ("Analysis of Trends in Demand For, and Trade In, Different Qualities of Wheat" --CL 103/7 Restricted). An important quality attributed not directly reflected in quality attributes is that of moisture content. This varies across exporting countries and classes, and is inversely related to the protein content. Thus, protein was adjusted to a constant 12 percent moisture basis using either specified or traditional levels of moisture for each class/origin. Due to the relative high moisture of CWRS, this imputes a larger negative effect on their protein level, but the transformation results in more accurate measures of protein content.

For each of the markets described above the data were pooled across types of wheat and through time. Thus the resulting model for estimation is a covariance model with binary variables included to account for cross-sectional discrete effects. Each model was estimated using ordinary least squares (OLS). In addition, selected models were estimated using Park's method which corrects for both heteroskedasticity and autocorrelated error terms, common problems with pooled data. This method assumes first-order autocorrelation with contemporaneous correlation between cross-sections.

The results are presented in Tables 5 and 6 for the different markets. In each case several models are presented depending on the inclusion of hard and/or spring. In general within this section, only results of the models including both winter and spring are discussed along with those models estimated using Park's method where appropriate. Due to missing price data at the U.S. Gulf prior to 1975/76, models using the Park method were estimated only for more recent years, and not at all in the case of the Rotterdam market.

The coefficient for spring varies across markets and is significant in each with the exception of the Pacific FOB market. The value of the coefficient indicates the value of spring relative to winter wheat. For example, in Japan the implicit value for spring wheat, holding all other characteristics constant, is $4.15/MT. These results suggest that from a demand perspective there are important differences between wheats with different growing habits which are reflected in the implicit values.

The country of origin variables in the CIF markets are generally significant suggesting that important differences in value are perceived across exporters. Of particular interest is the substantial premium for Canadian origin wheats relative to the U.S. origin wheats in the Rotterdam market, and relative to Australian wheat in the Japanese market. The implicit premiums over U.S. wheat in Rotterdam are about $14/MT, and about $9/MT over Australian wheat in the Japanese market. Factors which may contribute to the differences in implicit values could include various national pecularities in production/ marketing systems. The implicit value of U.S. wheat at Rotterdam is negative compared to Canada. In the Japanese CIF market all signs for U.S. origin are negative, but the t-values indicate lack of significance when using Park's method.

The implicit value of hard versus soft wheat is difficult to interpret because it varies by year and protein level. At the 13 percent protein level, the implicit value of hard versus soft at the U.S. Gulf was $8.96/MT, $17.15/MT, and $6.36/MT in 1973/74, 1982/83, and 1985/86 respectively. The same derivation at the Rotterdam market resulted in an implicit premium for hard wheat of $5.45/MT in 1973/74, which increased to $15.59/MT in 1982/83.

TABLE 5. HEDONIC MODELS OF U.S. FOB EXPORT PRICES

Variable	U.S. Gulf Model 1	2	3	4	Pacific Model 1	2	3	4
Intercept	10.73*	23.88*	10.75*	-7.27	6.26*	33.97*	16.56*	14.44
	(10.87)	(2.21)	(1.30)	(.47)	(0.81)	(2.58)	(1.70)	(1.58)
IWC	0.82*	0.74*	0.82*	0.95*	0.89*	0.72*	0.83*	0.84*
	(20.90)	(10.63)	(15.50)	(10.02)	(17.60)	(8.65)	(13.48)	(14.58)
Spring	10.95*	--	10.95*	14.82*	16.17*	--	14.91*	1.31
	(6.04)	--	(6.00)	(5.63)	(5.84)	--	(5.34)	(0.21)
Hard	--	-5.46	-0.01	9.73*	--	-17.42*	9.17	0.00
	--	(0.95)	(0.83)	(2.97)	--	(2.25)	(1.63)	(0.00)
Protein 73	0.69*	1.68*	.69	--	0.22	2.71*	1.09	1.30*
	(2.22)	(2.53)	(1.32)	--	(0.48)	(3.02)	(1.58)	(2.15)
74	1.19*	2.10*	1.19*	--	0.84*	3.17*	1.66*	2.42*
	(4.06)	(3.39)	(2.46)	--	(1.92)	(3.73)	(2.53)	(4.19)
75	1.30*	2.11*	1.31*	0.33*	0.86*	2.96*	1.60*	2.28*
	(4.76)	(3.76)	(3.00)	(2.53)	(2.06)	(3.74)	(2.63)	(4.54)
76	0.60*	1.14*	0.61*	0.04	0.25	1.81*	0.80	1.22*
	(2.23)	(2.44)	(1.71)	(0.01)	(0.61)	(2.57)	(1.53)	(3.46)
77	0.50*	1.03*	0.50	-0.11	0.05	1.61*	0.60	0.85*
	(1.85)	(2.22)	(1.42)	(-0.27)	(0.12)	(2.28)	(1.13)	(2.45)
78	0.70*	1.40*	0.71	-0.21	0.06	1.96*	0.73	1.01*
	(2.69)	(2.72)	(1.77)	(0.91)	(0.15)	(2.61)	(1.28)	(2.37)
79	1.32*	2.23*	1.32*	0.04	0.58	2.89*	1.37*	1.42*
	(4.55)	(3.62)	(2.76)	(0.69)	(1.32)	(3.41)	(2.13)	(2.50)
80	1.34*	2.34*	1.33*	-0.10	0.96*	3.47*	1.85*	2.12*
	(4.29)	(3.49)	(2.56)	(0.87)	(2.11)	(3.85)	(2.65)	(3.30)
81	1.56*	2.42*	1.56*	0.37*	0.67	2.90*	1.45*	1.66*
	(5.49)	(4.09)	(3.37)	(4.65)	(1.56)	(3.52)	(2.28)	(3.00)
82	1.32*	2.14*	1.32*	0.18	0.61	2.75*	1.37*	1.73*
	(4.76)	(3.75)	(2.98)	(1.50)	(1.45)	(3.43)	(2.22)	(3.35)
83	1.27*	2.09*	1.27*	0.12	0.54	2.67*	1.30*	1.71*
	(4.61)	(3.68)	(2.89)	(0.90)	(1.31)	(3.35)	(2.12)	(3.35)
84	1.01*	1.77*	1.00*	-0.06	0.62	2.64*	1.33*	1.48*
	(3.72)	(3.26)	(2.39)	(-0.35)	(1.49)	(3.41)	(2.24)	(3.08)
85	0.49*	1.21*	6.49	-0.47*	0.24	2.18*	0.92	1.35*
	(1.84)	(2.31)	(1.21)	(-2.15)	(0.58)	(2.88)	(1.60)	(3.01)
Adj. R^2	0.96	0.93	0.96		0.95	0.90	0.95	
Estimation	OLS	OLS	OLS	Parks	OLS	OLS	OLS	Parks

t-ratios in parentheses.

*Indicates significance at the 10 percent level.

TABLE 6. HEDONIC MODELS OF IMPORT PRICES CIF ROTTERDAM AND JAPAN

Variable	Rotterdam			Japan			
	1	2	3	1	2	3	4
Intercept	-12.53	-17.50	-23.85	-19.28	-12.37*	-15.96*	-18.43*
	(1.23)	(1.14)	(1.57)	(3.08)	(1.46)	(1.89)	(2.70)
IWC	1.06	1.08*	1.13*	1.23*	1.18	1.22*	1.24*
	(14.08)	(10.95)	(11.46)	(30.33)	(21.77)	(22.79)	(28.97)
Spring	6.80*	--	7.09*	7.49*	--	7.26*	4.15*
	(1.88)	--	(1.95)	(2.91)	--	(2.78)	(1.86)
Hard	--	6.32	7.53	--	-4.84	-2.86	-0.70
	--	(0.81)	(0.99)	--	(0.96)	(20.59)	--
Canada	14.60*	18.38*	14.47*	8.11*	14.62*	8.34*	9.45*
	(3.87)	(5.56)	(3.83)	(2.29)	(5.08)	(2.33)	(4.48)
U.S.	--	--	--	-4.28*	-2.61	-4.10*	-1.78
	--	--	--	(2.91)	(-1.33)	(2.09)	(0.79)
Protein 73	0.54	0.26	-0.16	0.39	1.00*	0.64	0.29
	(1.00)	(0.81)	(0.18)	(1.17)	(1.80)	(1.18)	(0.91)
74	0.54	0.29	-0.10	0.49	1.06*	0.74	0.57*
	(1.07)	(0.30)	(0.13)	(1.57)	(2.04)	(1.43)	(7.06)
75	1.34*	1.12	0.79	0.62	1.12*	0.83*	0.69*
	(2.94)	(0.35)	(1.10)	(2.05)	(2.36)	(1.78)	(3.09)
76	1.00*	0.86	0.66	0.79*	1.14*	0.93*	0.89*
	(2.34)	(1.57)	(1.20)	(2.57)	(2.80)	(2.35)	(8.51)
77	0.99*	0.86	0.65	0.23	0.59	0.38	0.30*
	(2.32)	(1.55)	(1.19)	(0.76)	(1.44)	(0.96)	(3.83)
78	0.68	0.50	0.21	0.37	0.81*	0.56	0.43*
	(1.59)	(1.54)	(0.33)	(1.23)	(1.83)	(1.27)	(2.37)
79	1.55*	1.31	0.92	1.35*	1.91*	1.58*	1.40*
	(3.14)	(0.77)	(1.15)	(4.25)	(3.68)	(3.10)	(5.02)
80	1.86*	1.59	1.16	1.55*	2.17*	1.81*	1.50*
	(3.47)	(1.62)	(1.31)	(4.64)	(3.88)	(3.29)	(4.67)
81	1.61*	1.38*	1.02	1.70*	2.24*	1.93*	1.71*
	(3.38)	(1.79)	(1.32)	(5.48)	(4.47)	(3.90)	(6.67)
82	1.16*	1.00	0.62	2.07*	2.58*	2.28*	2.07*
	(2.34)	(1.36)	(0.84)	(6.77)	(5.33)	(4.79)	(8.84)
83	1.58*	1.54*	1.04	2.04*	2.55*	2.26*	1.96*
	(2.69)	(1.97)	(1.32)	(6.70)	(5.29)	(4.75)	(8.44)
84	1.12*	1.09	0.61	1.23*	1.72*	1.43*	1.18*
	(1.93)	(1.44)	(0.80)	(4.11)	(3.69)	(3.14)	(5.63)
85	--	--	--	1.59*	2.04*	1.78*	1.51*
	--	--	--	(5.31)	(4.54)	(4.01)	(7.96)
Adj. R	0.94	0.94	0.94	0.96	0.96	0.96	
Estimation	OLS	OLS	OLS	OLS	OLS	OLS	Parks[1]

t-ratio in parentheses.
*Indicates significance at the 10 percent level.

The implicit value of protein varies by year and only applies to hard wheats, thus the coefficients (β_{yr}) can be interpreted directly. In Japan, for example, the implicit value of a 1 percent unit of protein increased from $.57/MT in 1974/75 to $1.96/MT in 1983/84. At the U.S. Gulf the implicit value increased from $.69/MT in 1973/74 to $1.31/MT in 1975/76. In general, significant implicit premiums for protein were observed in each market except for Rotterdam (Models 2 and 3). This exception may be due to the limited trading of Hard Red Winter resulting in protein premiums being implied in the spring variable.

The implicit values for protein vary through time, however, there is a general upward trend suggestive of a structural shift in the value of protein. Beginning in about 1979/80 to recent, the implicit values of protein have increased substantially in each of the U.S. markets, and in the Japanese CIF markets. The average implicit value of protein in Japan, for example, increased from $.53/MT per percent in 1974/74-1978/79 to $1.61/MT in subsequent years.

Summary

An important factor influencing demand for wheats of different qualities is the variability in relative prices. In the period prior to 1973/74, price differences in international markets were relatively small, likely reflecting the supply/demand situation and the lack of need to distinguish between different classes of wheat. Since then price differentials have increased dramatically in nearly all markets reflecting the increased differentiation in the international market. Notable increases have occurred in stronger wheat prices (HRS and CWRS) relative to all other classes. Of particular interest is that the relative increase in CWRS exceeded that of HRS.

Implicit values of certain quality characteristics are of interest because all other effects are held constant. There are several specific results of interest. First, it appears that there is an implied value for spring planted wheats relative to winter, even while holding other factors (e.g., protein, content, etc.) constant. Second, there are substantial implicit premiums for CWRS, or discounts for U.S. wheats. Third, the implicit premiums for hard wheats over soft has been diminishing in recent years. Fourth, the implied value of protein varies through time but has been gradually increasing in the past decade.

IV. Cross-Sectional Demand Analysis

Previous studies suggested that prior to the mid-1970s a relatively large proportion of international wheat trade was in blending wheats. Since then that proportion has alledgedly decreased due to technical changes in the milling industry, and to changes in the mix of importers. The relative importance of developing countries has increased and these countries generally consume products not requiring traditional blending wheats. Several other studies have also suggested that through 2000 there will be limited growth in developed countries, and most of the growth in world grain trade will be from developing countries. The purpose of this section is to examine the role of income on the class of wheat purchased. In addition, the importance of the level of per capita domestic wheat production is examined. The logic behind this is that countries with higher wheat production may have different requirements regarding imported wheat quality than those with little or no domestic production. Cross-sectional data of a selected group of countries is used to analyze these relationships.

The scope of the analysis was limited to the availability of consumption data. Data were collected for a selected group of countries on imports by class and country of origin, total wheat consumption, food consumption of wheat, income, and domestic production. All data were from 1984/85 and nonprice data were converted to per capita figures. Income was converted to U.S. dollars to correspond to price data. Data sources include International Wheat Council, Food and Agricultural Organization of the United Nations, U.S. Department of Agriculture and the International Monetary Fund.

Countries representative of wheat producers and importers with different income levels were selected. Chosen countries are shown in Table 7 with comparison of selected data to those of the major wheat exporters. Bread prices range from 40¢/kg in Pakistan to 188¢/kg in Sweden. Per capita consumption for food ranges from 47 kg in Brazil to 163 kg in Greece, compared to 86 kg in the U.S.

The study by Woodhams indicated a tendency for high income countries to use relatively more wheat for feed use. The logic to this is that in times of wheat surpluses the price differential between wheat and coarse grains may be reduced to the point where feeding wheat becomes economical, and generally only high income countries can afford to feed large livestock populations. The average percent wheat used for food was 73 for the countries shown in Table 7. The relationship between food utilization and income was estimated as:

$$\begin{array}{llll} \%F = & 0.87 \; - & 0.0264Y & \qquad R^2 = .24 \\ & (11.88) & (2.48) & \end{array}$$

TABLE 7. DATA ON SELECTED COUNTRIES WHEAT CONSUMPTION

Country	Bread Price	Real Income	Wheat Consumption	
			Total	Food
	US¢/kg	000 US$/Capita	-----kg/capita----	
Importers				
Austria	61	6.9305	112.848	71.788
Brazil	85	0.0540	47.518	47.518
Denmark	133	7.6354	342.857	92.368
Germany	96	8.7645	157.437	77.738
Greece	52	1.5632	185.930	163.819
Ireland	77	3.1068	210.734	112.994
Netherlands	78	7.2426	132.455	83.911
UK	53	5.7339	184.422	97.681
Japan	151	9.6621	52.216	51.033
Jordan	56	0.9351	117.262	117.262
Norway	173	9.2084	91.787	79.710
Pakistan	40	0.2305	133.247	133.247
South Africa	136	1.4330	69.065	64.025
Spain	49	2.6039	149.702	103.815
Sweden	188	8.0802	102.638	66.307
Switzerland	98	11.5979	121.118	91.149
Exporters				
Argentina	41	0.0130	152.824	150.332
Australia	106	7.9079	187.967	146.396
Canada	129	9.7567	207.043	107.561
France	129	6.0351	233.236	113.706
USA	177	12.3430	132.512	85.998

Where %F is the percentage of total wheat consumption devoted to food use, and Y is per capita income. T-ratios are in parentheses. The results indicate that there is a significant inverse relationship between the percentage of wheat used for food and income. For higher income countries, a smaller proportion of wheat utilization is for food, or they use relatively more wheat for feed. Lower income countries, on the other hand, consume a greater proportion of wheat as food.

The primary concern here is the influence of two variables, income and domestic production on wheat consumption patterns. To analyze these relationships the exporters were deleted from the sample, and all imports by class were converted to market shares. Consequently, the analysis does not evaluate factors influencing consumption levels, but rather factors influencing wheat importation patterns, or market shares by class.

Table 8 shows market shares by class of wheat imported. One apparent tendency is that CWRS, HRS, and EC wheat do relatively well in Western European countries. The simple correlations between market shares, income and domestic production are shown in Table 9. There are several points of interest. First, market shares for ASW and SRW are inversely related to income. The market shares for the stronger, high protein wheats are positively related to income, but not significant at the 10 percent level. Domestic wheat production is inversely related to Argentine and HRW market shares, but positively related with strong significance, to the CWRS market share. These results suggest that both income level and domestic production

TABLE 8. MARKET SHARES OF IMPORTED WHEAT CLASSES, 1984/85

Country	Argentina (ARG)	Australia (ASW)	Canada (CWRS)	European Community (EC)	U.S.				
					HRS	HRW	SRW	White	Durum
Brazil	.15	.00	.27	.01	.00	.54	.01	.00	.00
Denmark	.00	.00	.00	.00	.00	.00	.00	.00	.00
France	.00	.00	.73	.00	.02	.00	.00	.00	.23
Germany	.00	.00	.66	.00	.33	.00	.00	.00	.00
Greece	.00	.00	.00	.00	.00	.00	.00	.00	.00
Netherlands	.04	.00	.10	.00	.69	.00	.01	.00	.14
UK	.00	.00	.93	.00	.06	.00	.00	.00	.00
Japan	.00	.17	.23	.00	.17	.22	.00	.18	.00
Jordan	.13	.15	.00	.01	.00	.69	.00	.00	.00
Norway	.27	.00	.53	.19	.00	.00	.00	.00	.00
Pakistan	.02	.60	.00	.14	.00	.00	.04	.17	.00
South Africa	.03	.93	.00	.00	.00	.02	.00	.00	.00
Spain	.00	.00	.00	.00	.00	.00	.00	.00	.00
Sweden	.00	.00	.60	.40	.00	.00	.00	.00	.00
Switzerland	.00	.00	.36	.63	.00	.00	.00	.00	.00

TABLE 9. CORRELATION OF IMPORTED WHEAT CLASS MARKET SHARES, INCOME, AND DOMESTIC WHEAT PRODUCTION, 1984/85

Market Shares	Australia (ASW)	Canada (CWRS)	European Countries (EC)	Argentina (ARG)	U.S. HRS	U.S. HRW	U.S. SRW	U.S. White	U.S. Durum	Income	Domestic Wheat Production
Australia	1.0	--	--	--	--	--	--	--	--	--	--
Canada	- .52*	1.0	--	--	--	--	--	--	--	--	--
European Community	- .18	- .29	1.0	--	--	--	--	--	--	--	--
Argentina	- .04	- .22	- .14	1.0	--	--	--	--	--	--	--
U.S. HRS	- .18	- .13	- .26	- .12	1.0	--	--	--	--	--	--
HRW	- .02	- .38	- .24	.44*	- .15	1.0	--	--	--	--	--
SRW	.39	- .38	- .09	.08	.01	.05	1.0	--	--	--	--
White	.38	- .33	- .11	- .15	.01	.03*	.58*	1.0	--	--	--
Durum	- .18	.07	- .21	- .14	.38	- .17	- .04	- .14	1.0	--	--
Income	- .44*	.34	.13	- .13	.31	- .42	- .46*	- .03	.11	1.0	--
Domestic Wheat Production	- .27	.69*	- .12	- .47*	- .16	- .45*	- .19	- .25	.22*	.11	1.0

*Indicates significance at the 10 percent level.

have an influence on wheat import patterns. In simple terms, countries with relatively large domestic per capita production have a tendency to import a greater percentage of Canadian, and less Argentine and HRW.

A general model was specified to estimate the functional relationship between market share by class and the two variables, income and domestic wheat production. Income may have an effect because of its influence on ability to pay, as well as on tastes and preferences for wheat products. Imported wheat quality requirements may also vary for countries with differing levels of domestic wheat production. If domestic production increases there is potential for change from importing filler-type wheats to importing blending types. Many other factors may influence the class/origin of wheat purchases including grain politics, location, diplomatic relations, and relative prices. Exclusion of prices from the model is valid because in a cross-sectional model prices are about constant across observations. Prices differ by class but importers are assumed to pay the same prices for the same classes. The influences of income on market shares, then, can be isolated even though prices are not included (see Phlips, p. 104). Inclusion of prices would be equivalent to adding constants to the model.

The model was estimated using both linear and nonlinear relationships, but only results from the latter are presented. The general relationship is similar to that of the familiar Engle function in economics used to analyze cross-sectional consumption functions (Phlips). Our concern here, however, is with the factors influencing quality of wheat imported, consequently market shares are used as the dependent variables. The nonlinear model is in semi-logarithmic form which allows: 1) increases in market shares to diminish at higher income levels, and (2) the possibility of an income level below which market share of a particular class diminishes to nil. The models were estimated using seemingly unrelated regression (SUR) which accounts for potential cross-equation relationships via the error term. The system R^2 from the linear model was .51, while that of the semi-logarithmic was .84, confirming that the latter was more appropriately specified.[5]

Estimation results are presented in Table 10. The effects of income on market shares of HRW and SRW are negative and significant. This suggests that lower income countries tend to import relatively more wheat of these classes. The coefficient for HRW is larger suggesting a greater response between income and market share for HRW than SRW. Income does not have a significant impact on the other wheat class market shares. Estimated coefficients for both HRS and CWRS do suggest positive relationships between market shares of these classes and income, however, these conclusions are of limited value due to the lack of significance.

Domestic wheat production also has impacts on imported wheat class market shares. There are significant, negative relationships between market shares for HRW and Argentine wheat and per capita domestic wheat production. This means that at higher levels of domestic production, or high degrees of self-sufficiency, relatively less HRW and Argentine is imported. The coefficient for HRW, is again, much larger suggesting a greater negative impact on HRW than Argentine. The only significant positive coefficient is for

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[5] These results should be treated tentatively since market shares rather than consumption levels were used as the dependent variable. Interpreted in this context the results strictly pertain to relative (i.e., across classes) consumption patterns. Further interpretation of the conclusions must be restricted being only a selected group of countries were used in the analysis (due to data limitations).

TABLE 10. CROSS-SECTIONAL MARKET SHARE FUNCTION BY WHEAT CLASS[1]

	Intercept	Income Per Capita[2]	Domestic Wheat Production Per Capita
U.S. Wheat			
HRS	.13 (.77)	.043 (1.23)	- .020 (.53)
HRW	.59* (5.72)	-.048* (2.15)	- .101* (4.28)
SRW	.004 (.55)	-.005* (3.08)	.001 (.74)
White	.08 (1.53)	-.003 (.22)	- .013 (1.04)
Durum	-.03 (.61)	.005 (.39)	.013 (.95)
Australia (ASW)	.23 (.98)	-.06 (1.20)	- .009 (.17)
Canada (CWRS)	-.23 (.89)	.05 (.92)	.14* (2.30)
European Community (EC)	.05 (.18)	.021 (.38)	.019 (.33)
Argentina (ARG)	.17* (2.87)	-.006 (.47)	- .028* (2.02)

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[1] Estimated using seemingly unrelated regression. System R^2 = .84.
[2] Each independent variable measured in logarithms.

Note: t-ratios in parentheses.
* indicates significance at the 10 percent level.

CWRS, indicating that countries with higher per capita wheat production tend to increase their market shares of CWRS. The estimated coefficent for HRS, which typically is considered comparable in quality to CWRS, is negative and insignificant, suggesting that, in fact, differences between the two classes are perceived by importers. Generally, results indicate that requirements for imported wheat quality are influenced by a country's domestic wheat production.

Summary

There are several important results from this cross-sectional analysis of wheat class import demand. First, countries with higher per capita incomes tend to use higher proportions of wheat for nonfood purposes, especially feeding. Second, market shares for both HRW and SRW are inversely related to per capita income, and the HRW market share is also inversely related to domestic production. Third, CWRS market share, and to a lesser extent U.S. market share, tends to be greater in countries with higher incomes, and in countries with greater domestic wheat production. These results indicate that market shares of imported wheat classes are influenced to some extent by variables such as income and domestic wheat production, generally confirming the suggestions of others. Lower income countries tend to purchase cheaper wheats possibly either because of the reduced ability to pay, or because product consumption is such that they do not require the characteristics of stronger wheats. The level of domestic wheat production has had non-neutral impacts on wheat class market shares likely reflecting "blending" versus "filler" wheat requirements--i.e., higher levels of domestic production results in a positive shift to CWRS, and shift away from HRW and Argentine.

These results are from a selected group of countries, thereby limiting generalization. Further, dynamics of change are not captured and the results are merely a snapshot of the competitive environment of 1984. Generalization of results and conclusions across other countries is limited since only a selected group of countries was analyzed.

V. Time Series Analysis of Import Demand

In some markets the same class of wheat is always imported, or at least classes are imported in constant proportions. In others, the proportions of wheat classes imported vary substantially through time. Variations in imported wheat class shares may be attributable to relative prices among different classes. Variation in class shares may also be due to exogenous factors such as changes in incomes, wheat product preference patterns, the level of domestic production, or concessional sales. These characterizations are made based on the observed responsiveness of wheat class import shares to changes in relative prices. If highly price responsive, the market could be called price conscious, otherwise the market could be referred to as quality conscious even if not importing the most expensive wheat.

The purpose of this section is to analyze variability in imported wheat class market shares. A model was estimated using time series data for selected regions, countries, and the world. In the first section below, the methodology is briefly explained. Following sections include description of data, presentation of empirical results, and market share simulations. A summary is included in the final section.

Methodology

Most previous studies on wheat import demand have not addressed issues related to the heterogeneous nature of wheat, wheat markets, or quality preferences. Instead, most previous demand studies have focused on aggregate policy and aggregate demand. In general, there are two alternative approaches which can be used to analyze demand by wheat class. One uses general demand theory for commodities, and often concepts of duality to derive and estimate demand functions for consumers or producers. Berndt and Wood, Wilson, and

Swamy and Binswanger have used this methodology in the analysis of energy, transportation, and food demand, respectively. Rosscup applied duality to the analysis of wheat class import demands by the Pacific Rim countries. An alternative called the Case function approach has had limited use in empirical analysis. But this function is tailored for the analysis of the demand for differentiated products within a market--it bridges the gap between economic theory and the practical problem of evaluating market shares. The Case function is used in this study to explain variability in imported wheat class market shares, to derive measures of price responsiveness and preferences for different classes and types of wheat in several regional wheat import markets, and to simulate future market shares by class.

Case provided theoretical development of the market share function, by showing that it provides (1) an indirect means to measure product preference and (2) a straightforward method of evaluating market share price relationships. Subsequently, Houck and Ryan developed linear estimating equations which were applied to the international market for edible oils. The methodology is outlined here briefly with references to Case, and to Houck and Ryan for more detail.

The underlying assumptions of this demand model are that (1) products are close, but not perfect substitutes, so that individual competitors can sell at different prices, and (2) the probability that an individual buys from a particular supplier is related to the relative prices charged by that supplier and competing suppliers according to the logistic function. A system of market share demand equations can be derived with parameters indicating individuals' preferences towards products and one parameter indicating the price responsiveness of market shares. Market shares are related to relative prices and preferences. In a simple three good market the shares for goods 1, 2, and 3 are:

$$S_1 = \left[1 + \left(\frac{c_{12}P_1}{P_2} \right)^{\gamma} + \left(\frac{c_{13}P_1}{P_3} \right)^{\gamma} \right]^{-1}$$

$$S_2 = \left[\left(\frac{c_{21}P_2}{P_1} \right)^{\gamma} + 1 + \left(\frac{c_{23}P_2}{P_3} \right)^{\gamma} \right]^{-1}$$

$$S_3 = \left[\left(\frac{c_{31}P_3}{P_1} \right)^{\gamma} + \left(\frac{c_{32}P_3}{P_2} \right)^{\gamma} + 1 \right]^{-1}$$

where $S_1 + S_2 + S_3 = 1$, $c_{12} = 1/c_{21}$, $c_{13} = 1/c_{31}$, $c_{23} = 1/c_{32}$, and $c_{32} = c_{12}/c_{32}$. S_i represents market shares, P_i are prices ($i=1,2,3$). The c_{ij}'s and γ are parameters to be estimated. Figure 5 illustrates the nature of the Case function for good 1. As the price of good one (P_1) decreases relative to P_2 and P_3, the market share of good 1 approaches 1.

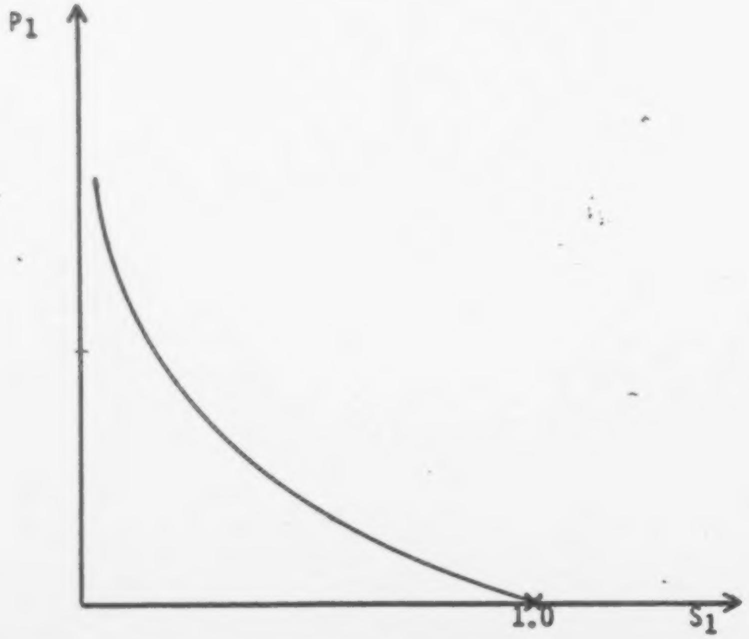

Figure 5. The Relation Between Market Shares and Prices

In the equations above, γ is a measure of price responsiveness. In fact, Houck and Ryan showed that γ is the elasticity of substitution. The market share functions above imply the following log-linear relationships between relative market shares and relative prices:

$$\ln\left(\frac{S_2}{S_1}\right) = \gamma \ln c_{12} + \gamma \ln\left(\frac{P_1}{P_2}\right)$$

$$\ln\left(\frac{S_3}{S_1}\right) = \gamma \ln c_{13} + \gamma \ln\left(\frac{P_1}{P_3}\right)$$

Thus γ indicates the percentage change in relative market shares that will occur when the corresponding relative prices change by one percent.

The c_{ij}'s measure the extent of differentiation in a market because they define the price premiums relative to good 1 that give all firms an equal market share. All c_{ij}'s are unity ($c_{12}=c_{13}=1$) in an undifferentiated market, and all suppliers have an equal (one-third) share when all products sell at the same price ($P_2/P_1=P_3/P_1=1$). The market has a weak preference for Product 1 when the c_{ij}'s exceed unity; suppose $c_{12}=1.1$ and $c_{13}=1.25$ in the three product case. Then each supplier has a one-third share if products 2 and 3 sell at 10 percent and 25 percent premiums over good 1 ($P_2/P_1=1.1$ and $P_3/P_1=1.25$). The market has a strong preference for Product 1 when c_{ij}'s are less than unity. For example, $c_{12}=0.9$ and $c_{13}=.75$ suggest that all classes have equal market share when classes 2 and 3 sell at 10 percent and 25 percent discounts from good 1 ($P_2/P_1=.9$ and $P_3/P_1=.75$).

Systematic changes in preferences are measured with exogenous variables that affect the c_{ij}'s. In this study, a trend variable, T, was included as a surrogate for the combined effects of several highly correlated variables:

$$c_{1j}=c_{1j}^{0}\,T^{d_{1j}}: j=2, 3$$

If the trend variable is indexed so that T=1 at the beginning of the sample period, then c_{1j}^{0} indicates the value of the preference parameter at the beginning of the estimation period and d_{1j} indicates the annual shift in the preference parameter. Equivalently, the effects on relative market shares can be accessed by substituting

$$\ln c_{1j}=\ln c_{1j}^{0}+d_{1j}\ln T, j=2, 3$$

into the log linear equations shown above. Note that the market share for class 1 moves inversely with a given c_{1j}, so a positive value for d_{1j} indicates that class j gains market share at the expense of class 1 due to nonprice factors.

Estimation can be based on the set of market share equations or the equivalent system of relative market share equations. The relative share equations can be based on linear methods, yield direct estimates of γ, and are amenable to the inclusion of several preference-shifting variables. However, this approach yields only indirect estimates of the c's. On the other hand, estimations based on market share equations must use nonlinear methods. Despite the complexities of nonlinear methods, this approach yields direct estimates of c's.

Both approaches were considered in this study. First, the linear specification was used to test hypotheses about the impacts of a number of exogenous variables on relative market shares. Each model was estimated using Seemingly Unrelated Regression (SUR) with restrictions of equality on γ across equations. The nonlinear market share functions were also estimated directly using the models including only relative prices and trend. Coefficients of the model were estimated using Iterative Nonlinear Seemingly Unrelated Regression (ITSUR) with one redundant equation dropped from each system. Values of parameters were restricted across equations to maintain consistency with Case's hypotheses.

Focus of the Empirical Study

Market share demand is based on a pliable theory which is suited to any retail or wholesale market. The present focus on wheat class shares in import markets is especilly convenient because complications arising from government intervention in domestic markets are avoided--importing agents will respond to wheat qualities and prices on the international market, even if domestic policy influences import requirements. Furthermore, a regional analysis is desirable for two reasons. First, relatively homogenous regions with respect to cultural practices and stages of economic development can be defined. Second, simultaniety problems are avoided because individual regions do not exert important influences on terms in the overall world market.

Wheat class import demands in four geographic regions are examined. These regions--Latin America, Asia (excluding Japan), the Middle East, and Africa--consist of developing countries. Results are also reported for a major import market, Japan, and the domestic market in the United States. Results for the overall world trade market are also reported for comparison purposes. One important factor in the world grain market, the Soviet Union, was excluded from the analysis. Here, complicating factors would likely carry the study beyond the issues of price response and quality characteristics (Appendix D).

Data Dimensions and Sources

Sources of data used in this study are discussed in this section as well as a description of the analytical dimensions. Reasonably consistent data sources were used, although this task is difficult because organizations sometimes change data collection methods. All data used in this time-series study were from secondary sources. Time-series data for the 24-year period, in international trade years (July/June), from 1961/62 through 1984/85 were collected for estimation.

Four regions are analyzed--Latin America, Asia (excluding Japan), Middle East, and Africa. The countries included in these regions are identical to the groupings in the International Financial Statistics 1986 Yearbook (IFS). Appendix Tables A7-A10 contain the listings of countries included in each region.

The major wheat classes traded in the world market and considered in this study include and are referred to in the remainder of the text with the acronym in parentheses: Argentina (ARG), Australia (ASW), Canadian Western Red Spring (CWRS), Canadian Amber Durum (CAD), European Community (EC), and U.S. wheats: Hard Red Winter (HRW), Hard Red Spring (HRS), Soft Red Winter (SRW), White (WHI), and Durum (DUR). Each was discussed earlier and their quality characteristics shown in Table 1.

Wheat imports by class were obtained from two sources. Import data for U.S. wheat classes were obtained from various issues of Grain Market News (GMN) published by the Agricultural Marketing Service, U.S. Department of Agriculture (USDA). Annual summary reports by U.S. crop year of inspections for export by class and country of destination were used as sources of import figures. Data for wheat and flour imports from Argentina, Australia, the EC and Canada were obtained from various issues of the International Wheat Council publication, World Wheat Statistics (WWS). These import figures were not broken down by class so all imports from a country were assumed to be of the dominant class. Durum imports, however, were identifiable and consequently excluded from exporter country totals. In one market, Canadian durum (CAD) imports were substantial enough to include as a separate class. Wheat class consumption figures for the United States were obtained from Wheat Situation (WS) publications by the Economic Research Service, USDA.

Various issues of WWS were the sources of wheat class price data with the exception of U.S. domestic prices. These were obtained from selected issues of WS. Table 11 contains the specific price series used to represent each class. All international prices are international trade year averages. In each country, region, and world, FOB prices were used with the exception of Japan in which C & F prices were used. In general, FOB prices are more conprehensively available than C & F prices and consequently were used. In estimation with the Case function, the use of FOB prices might bias estimates of the preference parameter levels but should not seriously affect results, as long as changes in relative freight costs are minimal. Prices used in the analysis of United States consumption were those from the dominant market for each particular class.

Income and population figures were obtained from International Financial Statistics 1986 Yearbook. Regional indexes for Gross Domestic Product (GDP) at constant prices contained in world tables were used for real income figures for all regions. Each regional index is a geometric mean of

TABLE 11. WHEAT CLASS PRICE SERIES USED BY MARKET

Market	Wheat Class Representative Price
World, Latin America, Middle East, Africa	HRS: U.S. No. 2 DNS 14%, FOB U.S. Gulf
	HRW: U.S. No. 2 HRW Ordinary, FOB U.S. Gulf
	SRW: U.S. No. 2 SRW, FOB U.S. Atlantic
	WHI: U.S. No. 2 Western White, FOB U.S. Pacific
	DUR: U.S. No. 3 HAD, FOB U.S. Lakes
	ARG: Trigo Pan, FOB Argentina
	ASW: ASW, FOB Australia
	CWRS: No. 1 CWRS 13.5%, FOB St. Lawrence
	EC: EC Standard Wheat, FOB Rouen
	CAD: No. 1 CWAD, FOB Thunder Bay
Asia	HRS: U.S. No. 2 DNS 14%, FOB U.S. Pacific
	HRW: U.S. No. 2 HRW Ordinary, FOB U.S. Pacific
	WHI: U.S. No. 2 Western White, FOB U.S. Pacific
	SRW: U.S. No. 2 SRW, FOB U.S. Atlantic
	ARG: Trigo Pan, FOB Argentina
	ASW: ASW, FOB Australia
	CWRS: No. 1 CWRS 13.5%, FOB Canada Pacific Ports
	EC: EC Standard Wheat, FOB Rouen
Japan	HRS: U.S No. 2 DNS 14%, C&F Japan
	HRW: U.S. No. 2 HRW Ordinary, C&F Japan
	WHI: U.S. No. 2 Western White, C&F Japan
	ASW: ASW, C&F Japan
	CWRS: No. 1 CWRS 13.5%, C&F Japan
United States	HRS: U.S. No. 1 DNS 14%, Minneapolis
	HRW: U.S. No. 1 HRW Ordinary, Kansas City
	SRW: No. 2 SRW, Chicago
	WHI: No. 1 Soft White, Portland
	DUR: HAD (Milling), Minneapolis

Note: FOB is basis free on board.
C&F is basis cargo and freight.
DNS is dark northern spring.
HAD is hard amber durum.
Prices in U.S. market are domestic cash prices at major markets.

SOURCES: Prices in non-U.S. markets: International Wheat Council, *World Wheat Statistics*, various issues. Prices in U.S. Market: USDA, *Wheat Situation*, various issues.

included country indexes in national currency. Income figures for Japan and the United States were taken from their individual country pages. Population figures for each country and the separate countries included in each region were obtained from the individual countries.

Domestic production figures were obtained from various issues of WWS. Concessional total wheat imports from the United States were available in various issues of GMN and USDA data banks. These figures reflect wheat shipments from the United States under the PL-480 program. A shift variable on U.S. West Coast dock strikes was obtained from the study done by Gallagher et al. Two nongrade quality factors were also tested as explanatory variables. Hard Red Winter crop average protein was obtained from annual reports of Kansas wheat crop surveys. Crop average falling numbers for HRS wheat were obtained from annual reports of North Dakota HRS crop surveys.

Presented in Table 12 are the average market shares of the wheat classes imported by the seven regions and world markets.[6] Although HRW is a dominant class in each market, there is much variation among markets in the classes imported and their relative importance. U.S. HRW dominates in Latin America and the U.S., ASW dominates in Asia, CWRS in Japan, and EC in Africa and the Middle East. Historical market shares for selected classes in each market are shown in Figures 6-12.

The data presented in Table 13 show the historic, average growth rates for imported wheat classes by market. Total wheat imports have risen the

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[6] The classes of wheat shown in Table 12 were used in the analysis of market shares for each respective region. Market shares were derived using the total imports of the classes of wheat shown in Table 12 as the denominator.

TABLE 12. AVERAGE MARKET SHARE BY CLASS BY COUNTRY, REGION, AND WORLD, 1961/62-1984/85

	United States							Canadian		
Country/Region	HRS	HRW	SRW	WHI	DUR	ARG	ASW	CWRS	CAD	EC
	Percent									
Africa		26	9		10			8	6	41
Asia	6	21	9	16			24	23		
Latin America	12	45	4	1	2	20		13		3
Middle East		22	7	7			28	6		30
Japan	10	24		20			17	29		
United States	20	45	21	8	5					
World	6	23	5	7		6	15	24		12

fastest in Africa and the Middle East. Within each market the growth rates for individual classes have been highly variable. In Japan, for instance, where the growth rate for total imports has been 3.3 percent, HRS has experienced the highest growth rate by far of 24.6 percent. This figure, however, is relatively high because in early years HRS imports were nil. Other classes with higher than average growth rates over the time period were HRW and ASW. Significantly below average was the growth rate for CWRS, a class normally considered to be a major competitor to HRS. In Africa the fastest growth has occurred in United States and Canadian durum wheats while the hard wheats HRW and CWRS have shown below average growth. In the United States, Durum and HRW have above average growth rates in consumption, with HRS a lower than average growth. These variations in growth rates within and between markets suggest that underlying demand functions for wheats differ by class and market.

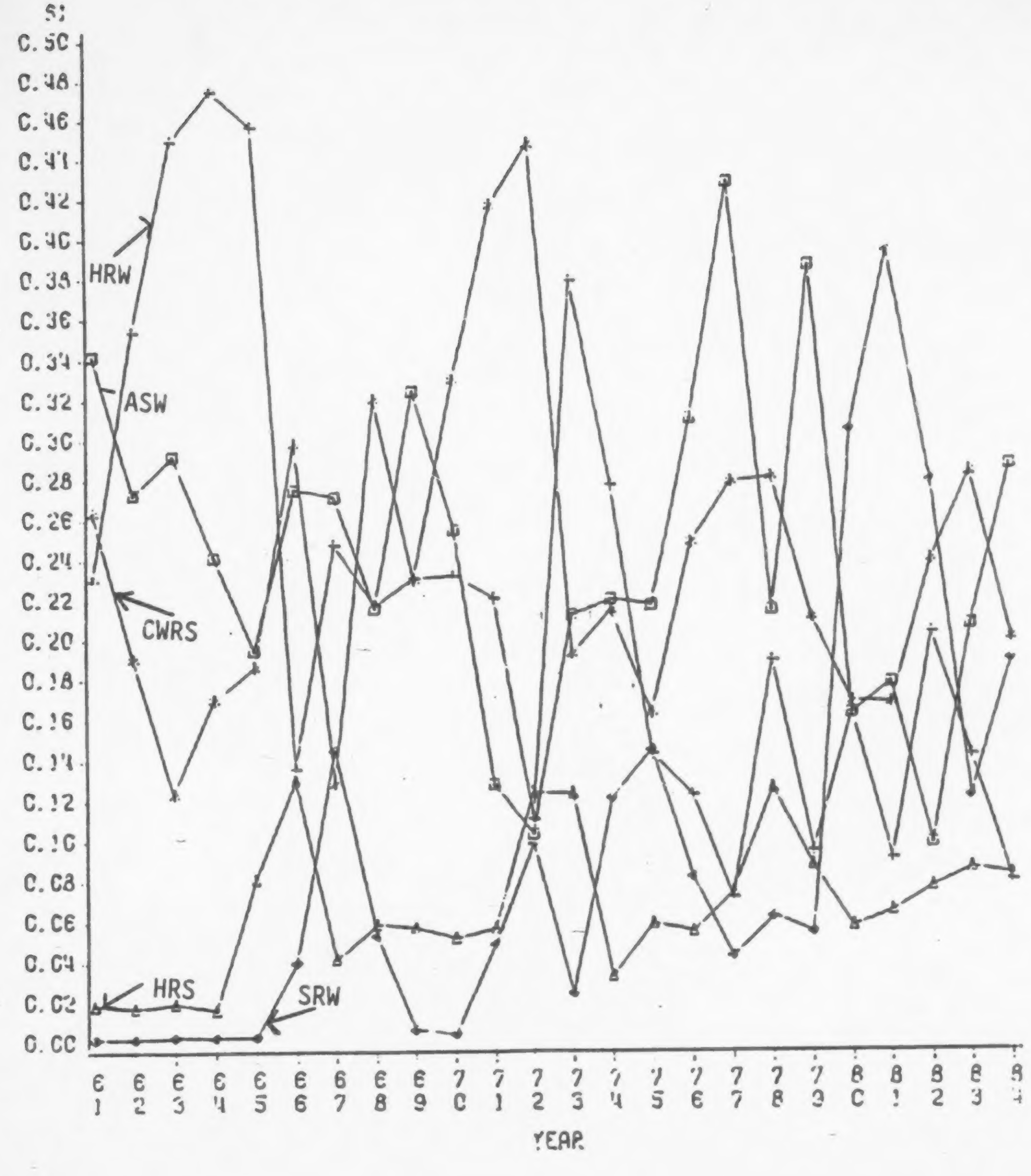

Figure 6. Wheat Class Import Market Shares for Asia, 1961/62-1984/85

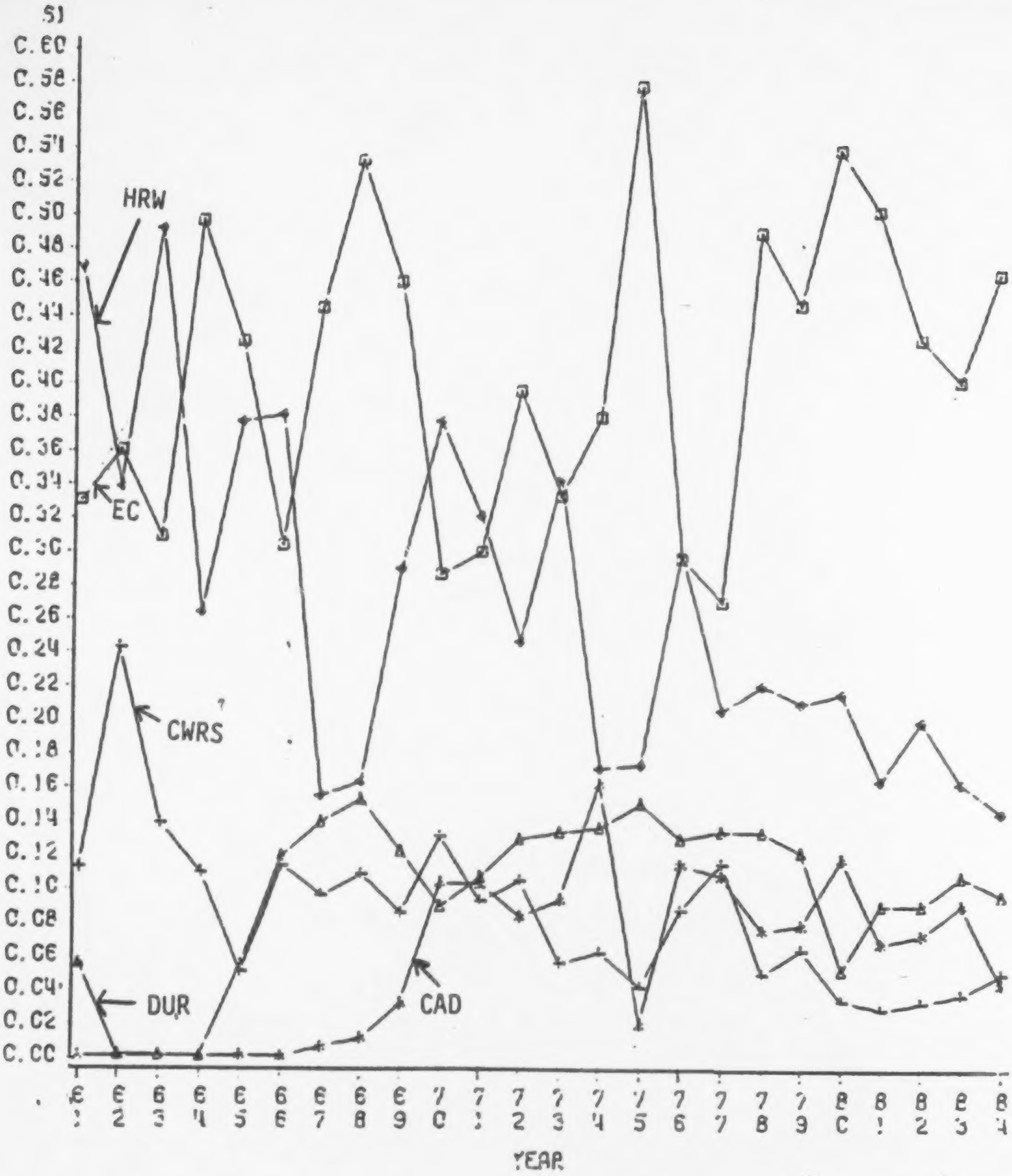

Figure 7. Wheat Class Import Market Shares for Africa, 1961/62-1984/85

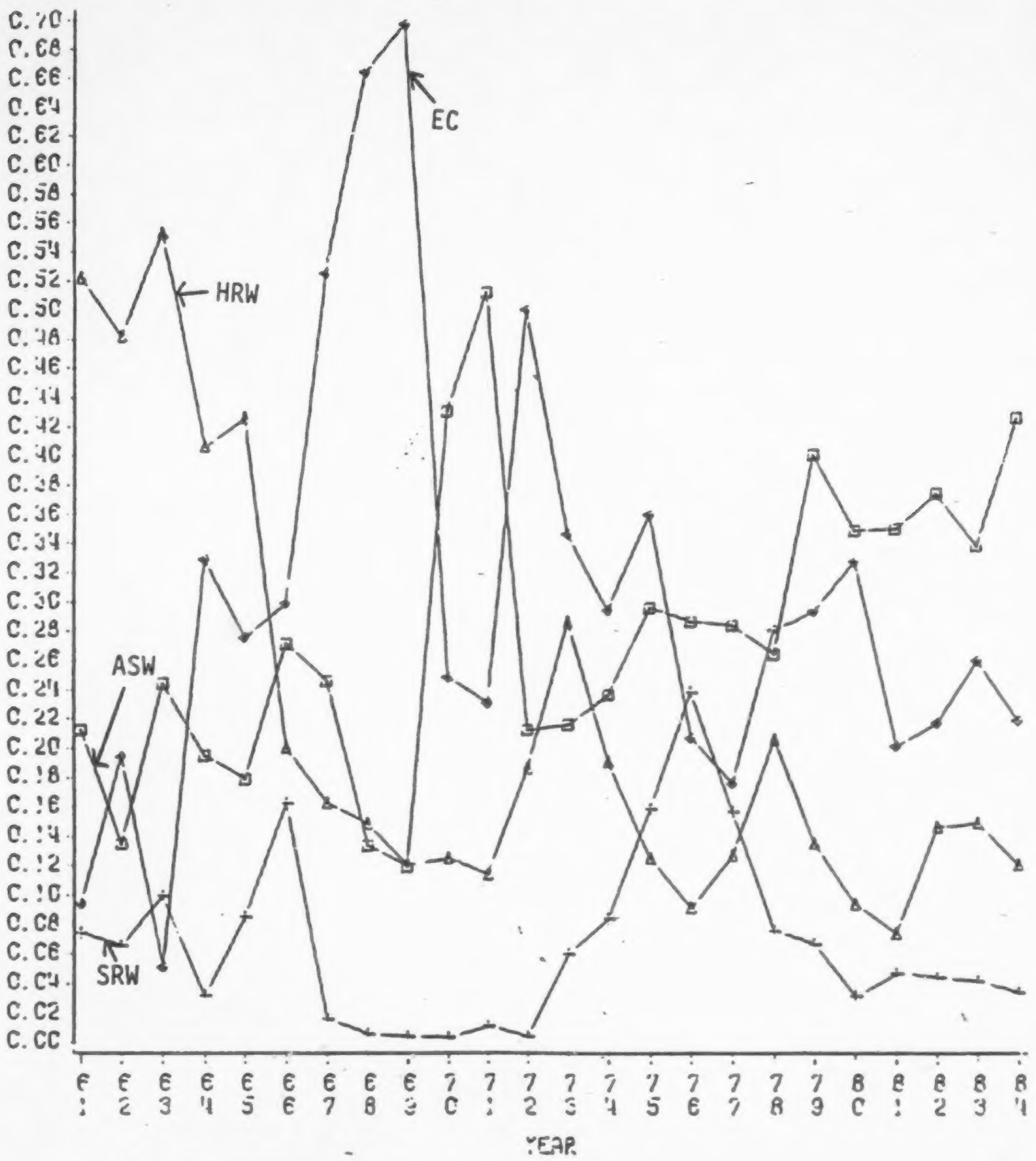

Figure 8. Wheat Class Import Market Shares for Middle East, 1961/62-1984/85

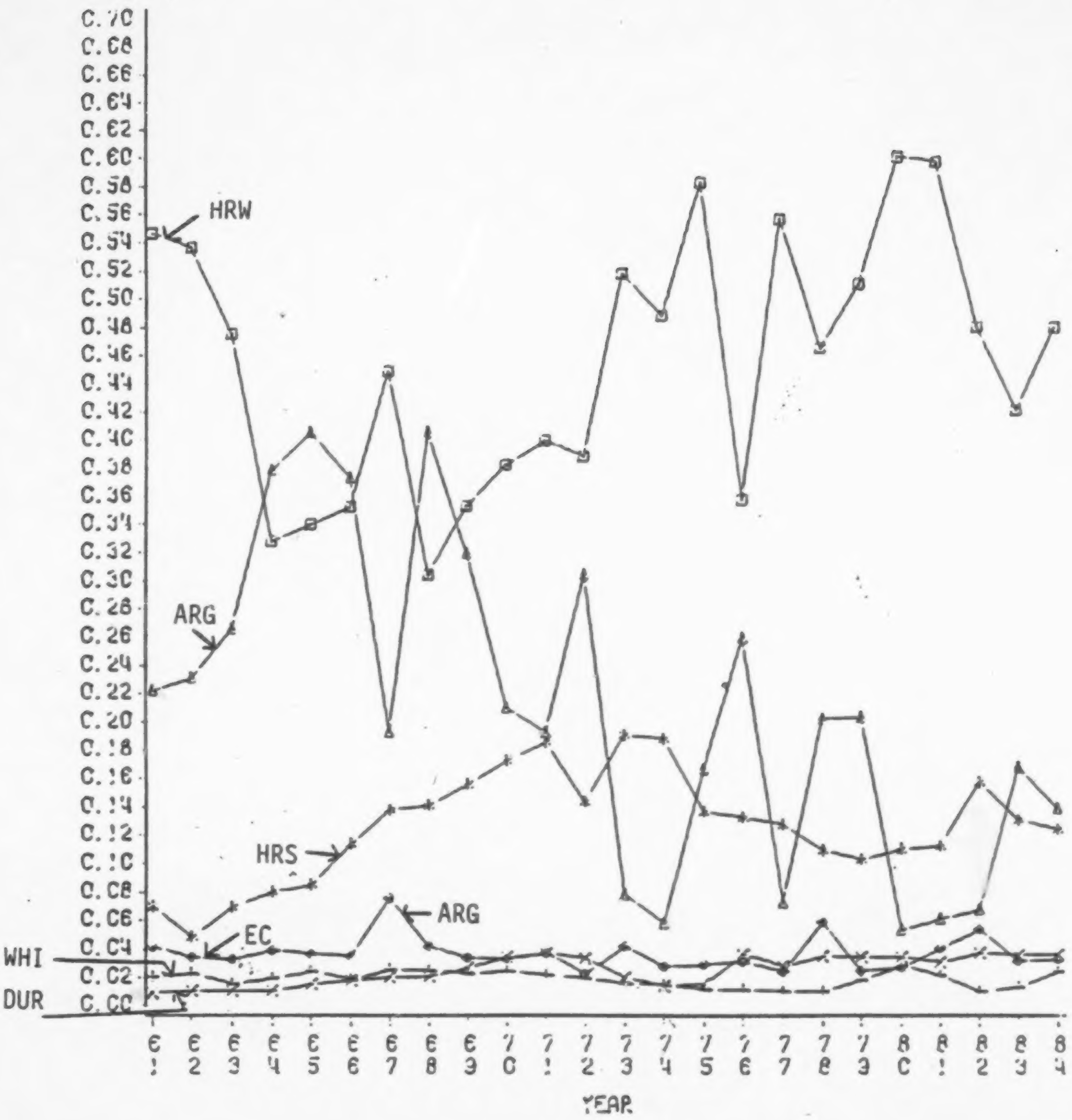

Figure 9. Wheat Class Import Market Shares for Latin America, 1961/62-1984/85

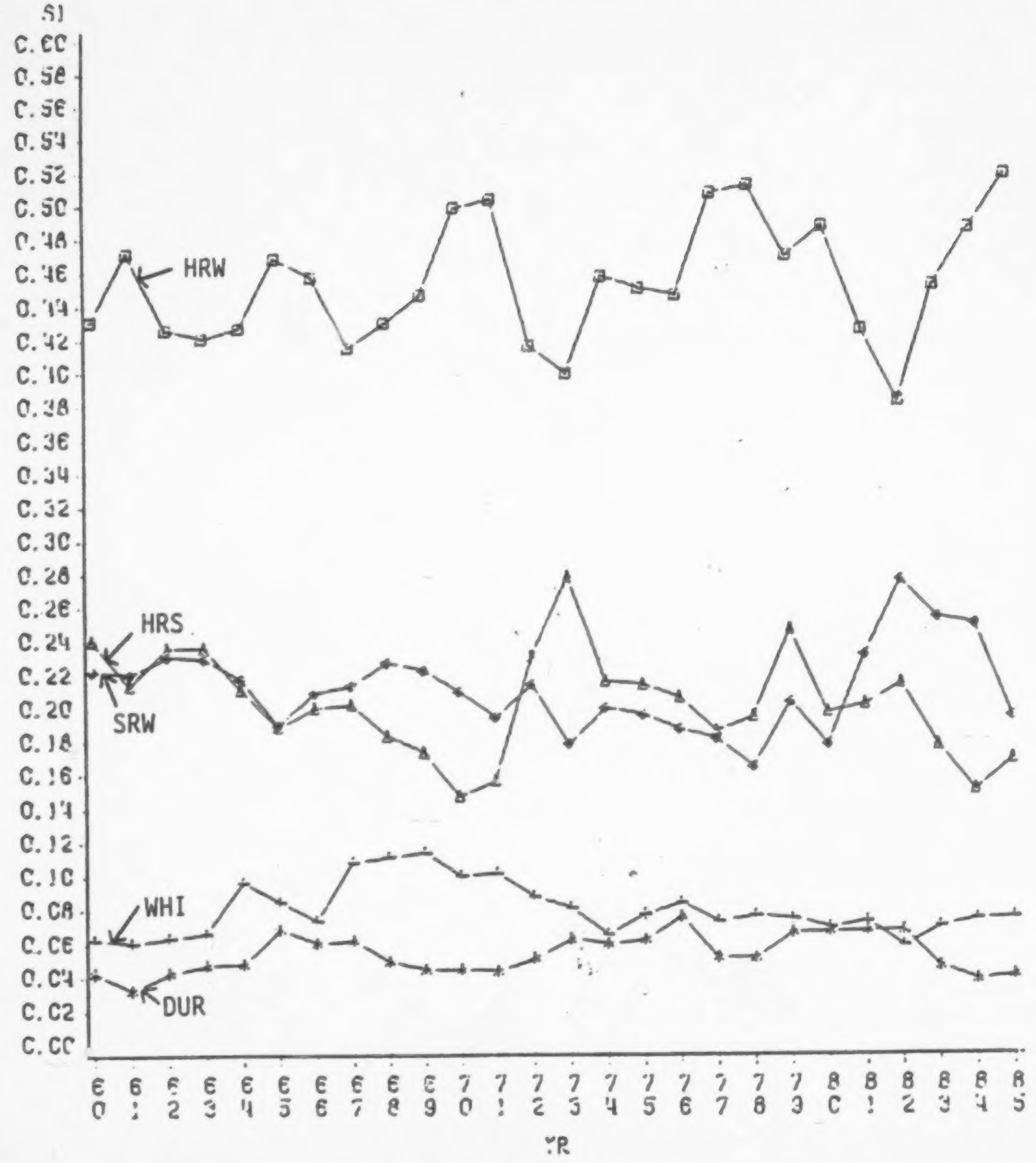

Figure 10. Wheat Class Consumption Shares for United States, 1960/61-1984/85

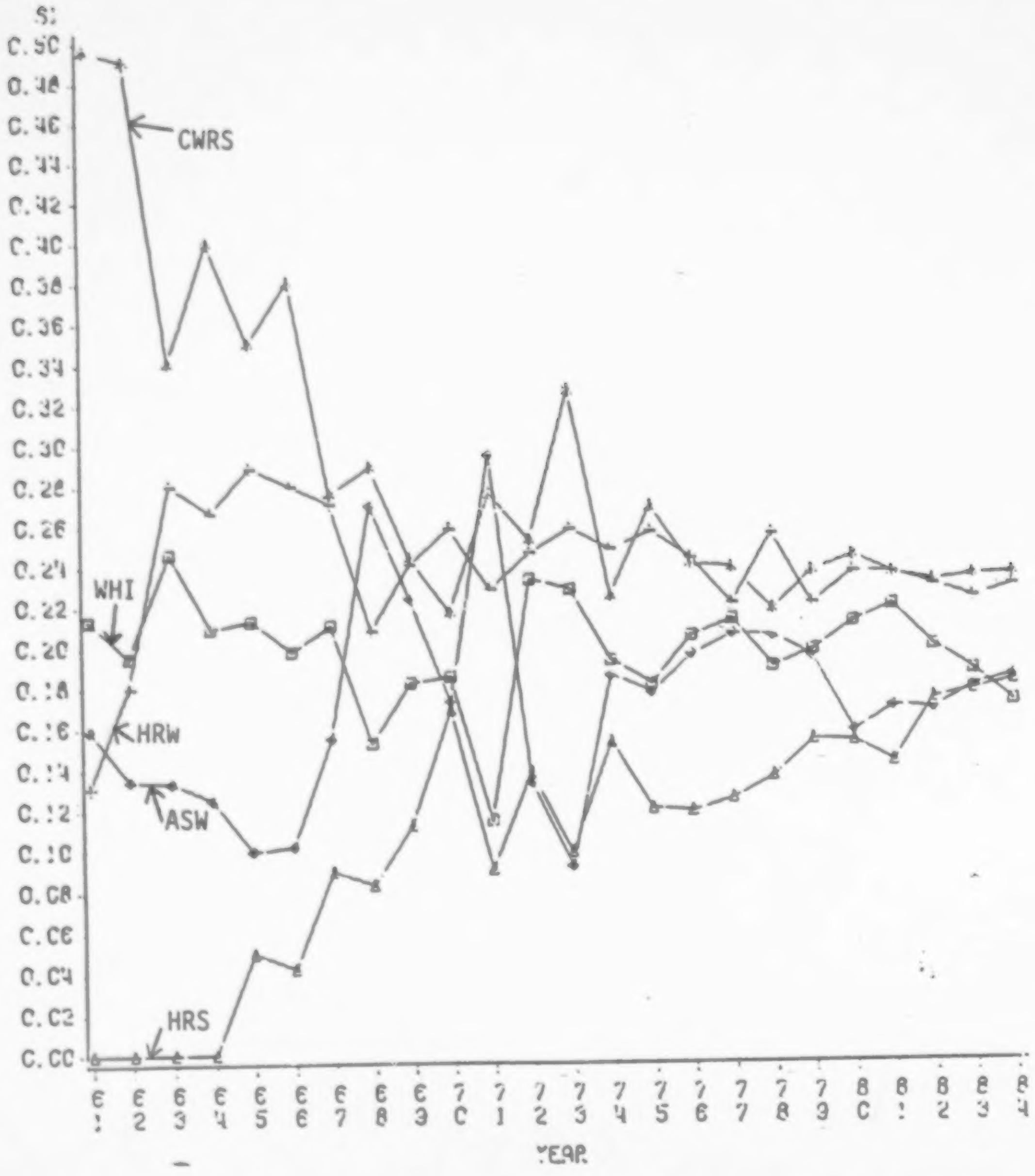

Figure 11. Wheat Class Import Market Shares for Japan, 1961/62-1984/85

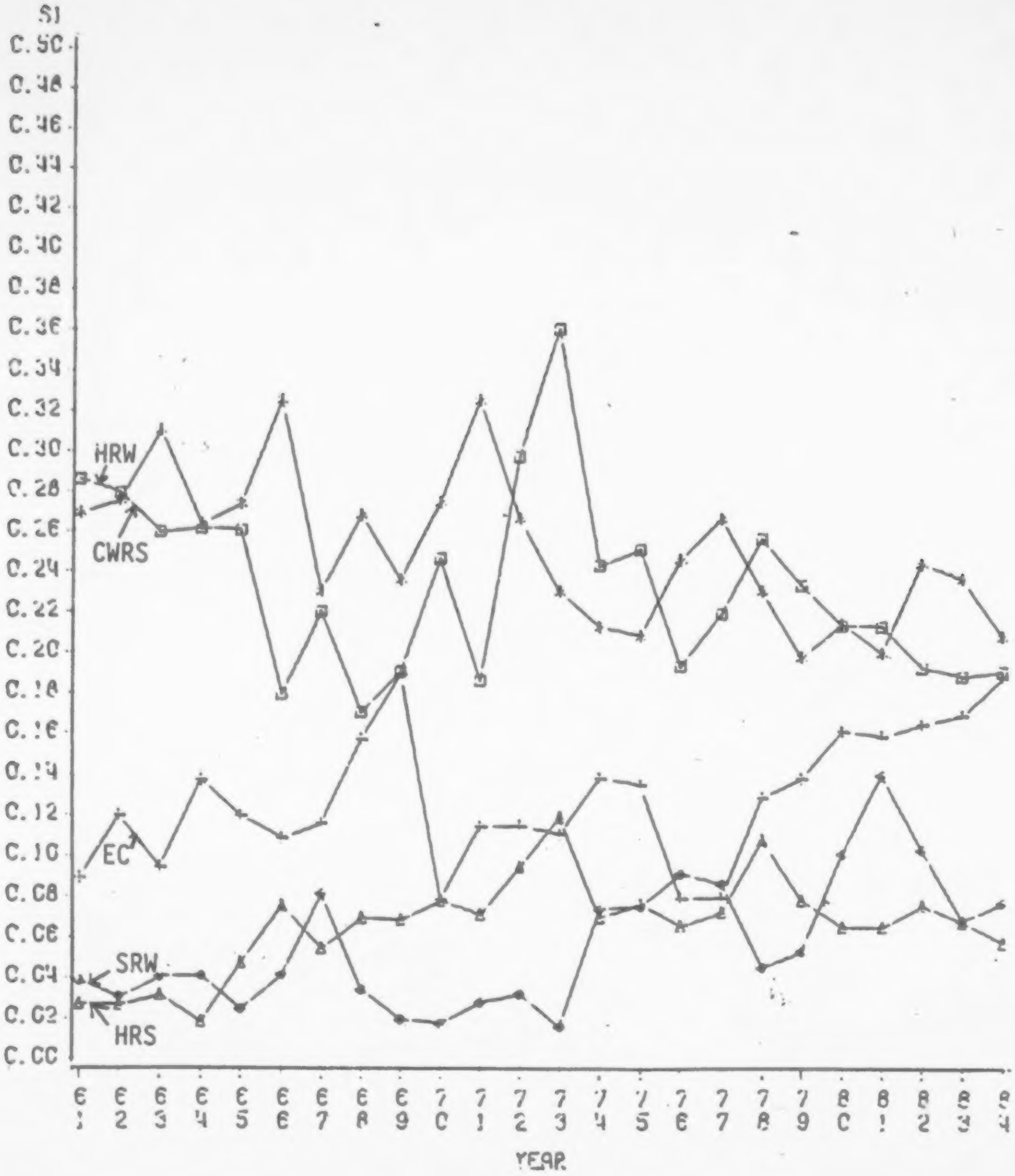

Figure 12. Wheat Class Import Market Shares for World, 1960/61 1984/85

TABLE 13. AVERAGE GROWTH RATES[1] OF WHEAT CLASS IMPORTS BY COUNTRY, REGION, AND WORLD, 1961-1962 THROUGH 1984-1985

Country/Region	United States					ARG	ASW	Canada		EC	Total Imports	Consumption
	HRS	HRW	SRW	WHI	DUR			CWRS	CAD			
	Percent											
Africa		5.2	13.0		19.1			2.9	33.1	9.8	8.9	
Asia	9.2	-3.3	34.8	3.0		5.9	1.1	2.8		3.6	2.4	
Latin America	7.5	6.0	5.7	-0.3	17.2	-1.1		7.6		3.2	5.1	
Middle East		3.2	9.2	18.1			12.9	15.2		10.6	9.5	
Japan	24.6	3.6		2.8			4.3	0.20			3.3	
United States	1.4	2.4	1.9	2.1	2.6							2.1
World	8.5	3.0	8.6	3.6		4.3	3.3	2.7		6.0	4.0	

[1] Derived from a simple regression of $\log Q_i = \gamma + \beta \cdot T$ using autoregression techniques. Q_i is annual imports of class i, T is time trend, and β is the growth rate and the reported coefficient.

Presented in Tables A11-A13 are the growth rates of and correlation coefficients between variables from each market which are potentially important in the structure of wheat class import demand. The variables included are trend, population, per capita income, domestic wheat production, concessional imports, and total wheat imports. With the exception of wheat production in Japan and concessional imports to the Middle East, all markets are experiencing negative growth rates in concessional imports and positive growth rates in all other variables. Correlations between these variables tend to be quite high expecially between any combination of trend, income, and production. This collinearity makes the detection of changes in import behavior attributable to any single one of these variables very difficult.

Results

Preliminary estimations were based on the log-linear system of relative market share equations. Several hypotheses about preference-influencing factors were considered. In general, estimates of separate effects for per capita income, domestic production, and concessional imports could not be obtained due to multicollinearity but such measurement was successful in a few regions. Subsequent estimations used a time trend for an estimate of combined effects. Also, quality measures, such as HRW protein and HRS sprout damage (falling numbers), influenced regional market shares in some instances. These preliminary results are discussed in Appendix B.

Table 14 contains the direct estimates of market share functions which were based on the nonlinear method. These representative results provide measurements of price response, the extent of wheat class differentiation, and secular changes in preferences by market. The wheat class with the largest market share in each region is identified as the base class (Class 1). Then

TABLE 14. WHEAT CLASS MARKET SHARES: NONLINEAR ESTIMATES OF CASE FUNCTION PARAMETERS BY MARKET, 1961/62-1984/85

Region (market)	Price Response γ	c^0_{12}	c^0_{13}	c^0_{14}	c^0_{15}	c^0_{16}	c^0_{17}	c^0_{18}	d^0_{12}	d^0_{13}	d^0_{14}	d^0_{15}	d^0_{16}	d^0_{17}	d^0_{18}
Africa	0.478* (1.9)	.00306 (0.28)	6.453 (0.82)	0.599 (1.30)	.0097 (0.37)	.00035 (0.21)			0.920 (1.05)	-1.229* (1.77)	-0.867* (1.76)	0.386 (0.75)	1.631 (1.36)		
Asia	5.55* (6.07)	0.908* (20.82)	0.295* (2.13)	1.134* (19.9)	0.689* (9.27)	1.023* (16.59)			.0091 (0.48)	0.368* (2.36)	-.061* (2.50)	0.098* (2.90)	0.060* (2.33)		
Latin America	.874* (3.98)	0.103 (1.49)	0.338 (1.08)	1.909* (2.18)	0.105 (1.32)	0.183 (1.69)	0.183 (1.65)	.00256 (0.63)	-.305* (1.80)	-.438* (2.03)	-.681* (2.69)	-.227 (1.07)	0.115 (0.73)	0.182 (1.16)	0.899* (2.96)
Japan	0.594* (2.19)	0.388 (1.01)	2.384* (2.06)	0.0098 (0.46)	7.015 (1.08)				0.296 (0.83)	-.178 (1.34)	1.449* (2.18)	-.491* (1.80)			
United States	1.23* (6.46)	0.578* (9.38)	0.240* (4.15)	0.711* (9.16)	0.175* (3.20)				-.045 (1.64)	0.022 (0.50)	-.093* (2.54)	0.069 (1.16)			
World	1.269* (6.9)	0.071 (1.68)	0.330* (5.11)	0.375* (4.93)	0.575* (6.14)	0.287* (3.36)	0.171* (3.22)	1.174* (8.91)	0.585* (3.23)	0.086* (1.73)	0.229* (3.40)	0.083* (1.31)	0.082 (0.83)	0.343* (4.28)	0.015 (0.31)

*Indicates significance at 10 percent level.

Key: Africa 1=EC, 2=SRW, 3=HRW, 4=CWRS, 5=DUR, 6=CAD
Asia 1=ASW, 2=WHI, 3=SRW, 4= HRW, 5= HRS, 6=CWRS
Latin America 1=HRW, 2=EC, 3=WHI, 4=ARG, 5=SRW, 6=HRS, 7=CWRS, 8=DUR
Middle East 1=ASW, 2=EC, 3=SRW, 4=WHI, 5=HRW, 6=CWRS
Japan 1=WHI, 2=ASW, 3=HRW, 4=HRS, 5=CWRS
United States 1=HRW, 2=SRW, 3=WHI, 4=HRS, 5=DUR
World 1=HRW, 2=SRW, 3=WHI, 4=EC, 5=ASW, 6=ARG, 7=HRS, 8=CWRS

the preference parameter relative to the base class (c_{1j}), is expressed as the product of the intercept (c^0_{1j}) and trend multiplier (T^{d1j}) which indentifies the competing classes' preference gains relative to the base class.

Estimates of substitution elasticities (or price response parameters) are presented in Table 15. The t-values for these price response parameters are high for all markets (from Table 14), suggesting that relative prices do influence market shares. Results for the Middle East are excluded from Table 14, but the analysis pointed to the conclusion that relative prices are not significant determinants of market shares in the Middle East.[7]

TABLE 15. PRICE RESPONSIVENESS OF WHEAT CLASS MARKET SHARES TO RELATIVE PRICES IN IMPORT DEMAND BY MARKET, 1961/62 THROUGH 1984/85

Market	γ
Africa	0.48*
Asia	5.55*
Latin America	0.87*
Middle East	0.07 1)
Japan	0.59*
United States	1.23*
World	1.27*

*Indicates significance at the 10 percent level.

1) From Appendix B.

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[7] Relative prices were not statistically significant in log-linear regressions and γ iterated towards zero but failed to converge in nonlinear estimations.

The magnitude of these elasticities varies widely across markets. The Asian import market is highly price conscious, with an elasticity estimate of 5.5. Market shares are moderately sensitive to relative prices in the overall world trade market (1.27) and in the domestic U.S. market (1.23). Estimates for the remaining regions, Latin America (0.87), Japan (0.59), and Africa (0.48), suggest that prices have a minor influence on market shares.[8]

The intercept and trend coefficients shown in the remaining columns of Table 14 indicate levels for and changes in the preference parameters. The intercept estimates indicate the preference parameter values at the begining of the estimation period. These coefficients are statistically significant in all but a few cases. These coefficients are also shown in Table 16 with indications of each possible combination. The trend coefficients indicate the secular increase in c_{1j}, or the market share gain of class j at the expense of class 1 and suggest that secular changes in preferences are important for some classes in some markets.

Significant trend variables indicate that underlying trends are causing shifts in market shares and, consequently, in wheat class preferences. These trends are net of price effects and are interpreted as nonprice shifts in import shares. These shifts are attributable to variables such as income and/or tastes and preferences, but the individual effects cannot be segregated due to the high degree of collinearity. Trend coefficients which are not significant indicate no shifts in market shares and preferences are occurring between those class pairs.

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[8] The price elasticity of demand is an alternative measure of the extent of demand response to prices. These elasticities were calculated for all results. Elasticity estimates are provided in Appendix C.

In the total world market the preference for HRW wheat has either been stable or has been shifting away from the importation of this wheat class. Of particular interest are the shifts toward SRW and EC, both soft wheats, and toward HRS. Other shifts are not statistically significant. A few region or country specific observations can be made from the results. Most notable in Asia is the shift away from ASW and toward U.S. SRW, and to lesser extents toward U.S. HRS and CWRS. In Japan, there are unequal shifts away from HRW and CWRS, but toward HRS. While HRW is already the dominant class in U.S. wheat consumption, preferences are shifting towards increased HRW consumption at the expense of HRS.

The results presented in Table 16 indicate that preference shifts through time, holding price effects constant, are occurring in many markets. These shifts may be reflective of changes in income, domestic production, technology, or tastes and preferences. In the world market shifts are toward both soft wheats, including SRW and EC, and stronger wheats such as HRS. However, in the U.S. domestic market, HRS is decreasing relative to HRW, possibly due to increased feed use. Patterns of shifts in preferences for imported wheat classes are different in each market. As incomes increase and/or tastes and preferences change through time, with the exception of the U.S. and Latin America, there are nonprice shifts away from HRW, toward either the soft wheats (EC and SRW) or the stronger wheats (HRS and CWRS).

Preference parameters (c_{ij}'s) were derived using results of the nonlinear models. The estimated parameters for each combination of classes are shown in Appendix Tables C8-C15 for selected years. No attempt is made to interpret all these coefficients. To summarize the results, the preference

TABLE 16. ESTIMATED TREND COEFFICIENTS FROM NONLINEAR MODELS OF IMPORTED WHEAT CLASS MARKET SHARES BY MARKET, 1961/62-1984/85

Market	Classes	Trend	Market	Classes	Trend	Market	Classes	Trend
Africa	EC,SRW	0.92	Asia	ASW,WHI	0.009	Latin America	HRW,EC	-0.31*
	EC,HRW	-1.23*		ASW,SRW	0.37*		HRW,WHI	-0.44*
	EC,CWRS	-0.87*		ASW,HRW	-0.06*		HRW,ARG	-0.68*
	EC,DUR	0.39		ASW,HRS	0.10*		HRW,SRW	-0.23
	EC,CAD	1.63		ASW,CWRS	0.06*		HRW,HRS	0.12
							HRW,CWRS	0.18
							HRW,DUR	0.90*
Middle East	ASW,EC	-0.02	Japan	WHI,ASW	0.30	United States	HRW,SRW	-0.05
	ASW,SRW	-0.31		WHI,HRW	-0.78		HRW,WHI	0.02
	ASW,WHI	0.28		WHI,HRS	1.45*		HRW,HRS	-0.09*
	ASW,HRW	-0.83*		WHI,CWRS	-0.49*		HRW,DUR	0.07
	ASW,CWRS	0.14						
World	HRW,SRW	0.59*						
	HRW,WHI	0.09*						
	HRW,EC	0.23*						
	HRW,ASW	0.08*						
	HRW,ARG	0.08						
	HRW,HRS	0.34*						
	HRW,CWRS	0.02						

*Indicates significance at the 10 percent level.

SOURCE: Table 14.

parameters, with respect to the base class in each market, are shown in Table 17 for both the beginning and end of the estimation period. The deviation of of individual c_{1j}'s from unitary values and their dispersion within a given market indicate the extent of wheat class differentiation. On this classification, the Mid-east, Africa, and Latin America are highly differentiated markets. The U.S. domestic and World import market appear to be moderately differentiated. Preferences have changed substantially in the Asia and the Japan import markets.

The strongest preference for an individual wheat class is indicated by the c_{1j} with the largest value, or by c_{1j}'s that are consistently less than one for the base class. The dominant class (in an equal market share sense) at the beginning of the estimation period is defined by the intercept estimates. In the early sixties, HRW was the dominant class in the U.S., Asia, Africa, and the Middle East. The dominant class in Japan and the overall world market was CWRS. ARG was dominant in its own Latin American market. However, the estimates indicate some substantial changes by the mid-eighties. From Table 17, HRW retained dominance in the U.S. and Mid-east, gained dominance from ARG in Latin America but lost it in Asia and Africa. CWRS retained dominance in Japan and the overall world market but magnitudes have fallen.

Large changes in preference parameters between the early sixties and the mid-eighties generally correspond to trend coefficients from Table 16 that are statistically significant. In the overall world market, preference relationships involving HRW are either remaining stable or shifting away from the importation of this class--the shifts toward soft wheats, SRW and EC, and

TABLE 17. PREFERENCE PARAMETER ESTIMATES FOR 1961 AND 1984

Region (Market)	Year	Base Class[1]	c_{12}	c_{13}	c_{14}	c_{15}	c_{16}	c_{17}	c_{18}
Mid-east[2]		ASW	EC	SRW	WHI	HRW	CWRS		
	1961		3.12	1.7×10^{-8}	1.1×10^{-16}	3.1×10^{9}	7.6×10^{-13}		
	1984		1.24	1.3×10^{-4}	3.8×10^{-21}	7.3×10^{25}	4.4×10^{-10}		
Africa		EC	SRW	HRW	CWRS	PUR	CAD		
	1961		.003	6.46	0.60	0.01	.0004		
	1984		.067	0.13	0.04	0.03	.062		
Asia		ASW	WHI	SRW	HRW	HRS	CWRS		
	1961		0.91	0.30	1.13	0.69	1.02		
	1984		0.93	0.95	0.94	0.94	1.24		
Latin America		HRW	EC	WHI	ARG	SRW	HRS	CWRS	DUR
	1961		0.10	0.03	1.93	0.10	0.18	0.18	0.003
	1984		0.04	0.01	0.22	0.05	0.26	0.33	0.04
Japan		WHI	ASW	HRW	HRS	CWRS			
	1961		0.39	2.41	0.01	7.14			
	1984		1.00	1.35	1.04	1.44			
U.S.		HRW	SRW	WHI	HRS	DUR			
	1961		0.58	0.24	0.71	0.17			
	1984		0.50	0.26	0.53	0.22			
World		HRW	SRW	WHI	EC	ASW	ARG	HRS	CWRS
	1961		0.07	0.33	0.38	0.58	0.29	0.17	1.17
	1984		0.45	0.43	0.78	0.75	0.37	0.51	1.23

[1] For each Region (market) the base class is given and preference parameters are shown with respect to each of. the authors.

[2] Indirect estimates for the Middle East were obtained from log-linear estimate shown in Appendix Table B4.

toward HRS, are particularly interesting. At a regional level, the Asian market does not show shifts between the white wheats, ASW and WHI. But HRW has been losing to ASW. All other classes, SRW, HRS, and CWRS are gaining in Asia. In Japan, there are shifts away from the initially preferred classes, HRW and CWRS, towards HRS and ASW. HRW has maintained dominance in the U.S. market. Here, preference has shifted slightly away from SRW and HRS, and slightly towards WHI and DUR.

The more precise interpretation of the c_{ij} is that the value tells what price ratio must exist between classes to achieve equal market shares. If the parameter value is greater than 1.00 then there is a stronger preference for the jth class. Besides providing information in and of themselves, c_{ij}'s can be compared across class pairs and through time. For example, in Table C12, the value in the Japan market of C15 is 1.44 in 1984/85. With five classes in the market, equal market shares means 20 percent for each class. The value 1.44 indicates that the fifth class (CWRS) would have to sell at a 44 percent premium over the first class (WHI) in order for both classes to have 20 percent (equal) market shares. The fact that C15 exceeds 1.0 indicates the extent of preference for CWRS relative to WHI, as reflected in the premium the former could command.[9]

Following are a few examples of the interpretation of preference parameters. The 1984/85 value of C12 is 1.00 revealing that in Japan preferences are the same for WHI (1) and ASW (2). Neither class is preferred above the other to the extent a premium could be commanded. In Asia this phenomenon occurs, also in 1984/85, amongst all four imported U.S. classes. The 12 c_{ij}'s involved, including, for example, C23, C34, and C53, range from .98 to 1.02 indicating very similar preferences between all of the four classes. Of particular interest is comparison of the c_{ij} of similar wheat types. For example, C15 and C16 in Asia were .94 and 1.24, respectively, meaning that CWRS is strongly preferred relative to U.S. HRS.

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[9] Care should be taken in interpretation of extreme values of C_{ij}'s. These are a result of abnormally large or small shares for either class and/or little price response. Even normal range of consumption patterns their shares differ substantially from equal market shares. Consequently, these are fairly strong or inveterate preferences for or against one of the classes and substantial changes in relative prices would be necessary in order to induce a shift in shares.

The c_{ij}'s can also be compared across class pairs. In any given year in the Latin American market there is a strong preference for the dominant class, HRW. This is indicated by all of the c_{1j}'s being substantially less than one, and all the c_{i1}'s being substantially greater than one. This even holds true for wheat from Argentina which is much closer to many of the Latin American countries, especially Brazil, than the United States. The second most preferred class indicated by inspecting the c_{1j}'s is CWRS. The 1984/85 value of C17 is 0.33, the largest in that row. Of particular interest in comparing c_{ij}'s across class pairs is when similar wheat types are involved. For example, the value of C56 in Asia (Table C8) in excess of 1.30 indicating the extent that CWRS is preferred relative to HRS. Similarly, there is a minimal preference for HRS relative to HRW (C45) but a significant and growing preference for CWRS to HRW. In Japan, Table C12, the results indicate a preference (albeit declining) for CWRS relative to HRS. Of interest also is that HRS is growing in preference relative to HRW (C34) but CWRS is declining in preference relative to HRS (C35).

Comparisons of c_{ij}'s through time reveal how preferences have changed, or stayed constant. In Table C14, the c_{2j}'s in the world market show how preferences between SRW and all other classes have changed. In the case of each class, there have been nonprice shifts in preferences towards SRW. These trends are indicated by the decreasing values of the c_{2j}'s through time. Literally, this means other classes of wheat need to decrease in price relative to SRW through time in order to have equal market shares. This can be interpreted as a growing preference in the world for wheat similar to Soft Red Winter. The strengthening preference for SRW in the world is not reflected equally in all markets. In Latin America, Table C10, SRW shows gains relative to some classes and losses relative to others. In Asia, (Table C80), which is expected to be a growth market of the future and which already accounts for a large proportion of trade, SRW has been the only class to consistently gain in preference over other classes. The values for C_{7j}'s in the world market indicate increasing preference for HRS relative to all other classes/origins, with the exception of SRW.

Simulations

The patterns of preference change could continue in the future. Then wheat class shares would change even in an environment of relative price stability because preferences determine demands. Potentially large or systematic changes in future class shares can be identified with the simulations presented in this section. The nonlinear models with trend and relative prices were used for simulation to obtain forecasts of wheat class market shares to the year 1995/96. In the simulation procedure current price levels[10] were used as the prices throughout the simulation period. Trend, then, was the only factor allowed to vary and determine simulated market shares. Table 18 contains a summary of these simulations. Each market is indicated by a row and columns indicate particular wheat classes. The projected change in market share over the 1985-1995 period is shown. Actual class shares in 1984 are also included for reference.[11]

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[10] For each class the 36 monthly prices from March 1983 to February 1986 were averaged together to determine current price level. Thus, the relative prices which are used in the Case function are those which existed during this period.

Asia experiences the largest and most numerous changes in market shares. By 1995, market share for SRW would increase by about 14 percentage points. HRS would maintain its share, but all other classes (ASW, WHI, HRS, and CWRS) would lose between 2.3 and 5 points. Relatively large changes in market share are also projected for Japan--HRS would gain 5 percentage points with offsetting decreases for HRW and CWRS. In the remaining regions, projected market share changes are smaller. In Latin America, for example, the only class that is expected to experience a change in market share greater than 1.0 point is ARG, which should lose 2.4 points.

Changes in wheat class market shares in the world market are summations of all the gains and losses for each class in each market, some of which were not included in this study. The largest predicted changes in market shares are an increase of 1.7 percentage points for SRW and a loss of 1.3 percentage points for HRW. Also, the competing classes HRS and CWRS are expected to experience slight market share changes in opposite directions, +.6 and -.9, respectively.

Some of the changes indicated by the world market results are reflected equally across markets. In particular, HRW consistently loses between two and four percentage points in all regional import markets except Latin America. But most other changes seem geographically concentrated. SRW, for example,

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[11] A more detailed presentation of market share changes is contained in Appendix Tables C16-C22.

TABLE 18. SIMULATED CHANGES IN WHEAT CLASS MARKET SHARES, 1985-1995

Region	Class:	HRW	SRW	WHI	EC	ASW	ARG	HRS	CWRS	DUR	CDUR
		percent (0/100)									
Africa											
1984 share		14.5	19.9		46.6				5.0	9.6	4.4
85-95 change		-3.1	1.6		-0.8				-0.8	0.1	3.0
Asia											
1984 share		7.2	18.3	19.1		28.5		7.5	19.3		
85-95 change		-4.0	14.3	-3.4		-4.3		-0.5	-2.3		
Latin America											
1984 share		48.0	5.4	1.5	2.4		13.0	11.5	15.5	2.7	
85-95 change		0.5	-0.2	-0.1	-0.2		-2.4	0.6	1.0	0.8	
Middle East											
1984 share		12.0	3.4	9.3	21.9	42.8			10.7		
85-95 change		-2.5	-0.3	0.8	0.6	0.8			0.6		
Japan											
1984 share		22.9		17.1		18.4		18.1	23.4		
85-95 change		-2.0		-0.7		-0.1		5.1	-2.5		
U.S.											
1984 share		48.7	25.0	7.5				15.1		3.8	
85-95 change		-1.0	0.0	0.6				0.2		0.1	
World											
1984 share		19.1	7.1	6.0	18.2	15.9	8.4	5.1	20.2		
85-95 change		-1.3	1.7	-0.1	0.5	-0.4	-0.1	0.6	-0.9		

gains 14.3 points in Asia, 1.6 points in Africa, and nominally in other markets. Similarly, HRS would gain 5.1 points in Japan while nominal changes would occur in all other markets.

Summary

Much variation exists among markets in the wheat classes imported, their relative importance, and historic growth rates. Thus, useful information can be obtained by analyzing class import demand on a less aggregated basis than the world market alone. Also, domestic production, income, and trend are highly correlated in most markets, so the separation of effects due to these factors is nearly impossible.

Market share demand relationships were estimated for several regional import markets, for the overall world trade market, and for the domestic market in the United States. Relative prices were significant determinants of market shares in all markets except for the Middle East. Furthermore, preference parameter estimates generally were significant and different in value indicating that different preference structures exist for individual wheat classes. Trend coefficients also were generally significant suggesting that shifts in preferences are taking place over time.

The c_{ij} parameters reflect relative preference among classes and dispersion about unitary values indicate the extent of wheat class differentiation. Very rigid class preferences are indicated for the Middle East, Africa, and Latin American import markets. Moderate class differentiation characterizes the world trade market and the U.S. domestic market. Class preferences in Asia and Japan are relatively undifferentiated, although differences between individual classes still exist.

The most prominant of the shifts in preferences are those away from the dominant HRW, and towards the weaker wheats (EC and SRW) or the stronger wheats (HRS, CWRS, and DUR). In the overall world trade market, for example, preferences shifted away from HRW and towards all other classes. Results from most regional markets are similar. In Asia, there are growing nonprice preferences for SRW, HRS, and CWRS relative to ASW, and HRW is losing. In Africa, SRW and durums are gaining preference relative to the EC, with HRW losing preference. In Japan, HRW and CWRS are both losing preference relative to WHI, whereas ASW and HRS are gaining. However, the Latin American market has strong preferences for HRW which is gaining slightly relative to soft wheats and ARG. Similarly, there are strong and relatively stable preferences for HRW in the U.S. domestic market.

Simulations of changes in wheat class market shares which extrapolate historical preference changes identify important changes. By 1995/96, the SRW share of the Asia market is expected to grow by 14 percentage points with losses between 2 and 5 percentage points for most other competitors. In Japan, the HRS share increases by +5 points. HRW consistently loses between 2 and 4 percentage points in all regional import markets, except Latin America. Market share changes are moderate in the overall world market, between -1.3 for HRW and +1.7 for SRW.

Every market to a certain extent is price and quality conscious and these results do indicate the relative importance of these competitive parameters. Asia is by far the most price conscious market. This is supported both by the large price responsiveness parameter, and the relatively uniform preference parameters. This is not to preclude quality from being important, but indicates that compared to other markets relative prices are very important determinants of market shares. Moderately elastic price response was found for the U.S. domestic market and the world trade market, where preferences are moderately differentiated. Latin America, Japan, Africa, and the Middle East (in declining order) are relatively less price responsive. This should not be interpreted that these markets have strong preferences for "high quality" wheat, however defined, but indicate unique preferences for particular wheat qualities that are unresponsive to changes in relative prices. Thus, these markets may be quality conscious in the sense of particular qualities, rather than necessarily a high-priced wheat.

VI. Conclusions

There are important indigenous and extraneous differences in wheat quality, both within and between exporting countries. These differences are due to the cumulative effects of tradition and agronomic practices, climate, variety development and release, regulations, and trading practices. As the competitive environment in the international wheat market intensifies, differentiation of wheat by quality characteristics is becoming increasingly important. If, simultaneously, there are changes in preferences by consuming countries, the ability to differentiate becomes especially important. The overall purpose of this report was to analyze the demand for wheat characteristics in selected markets. Results from previous studies were reviewed, and both cross-sectional and time series analysis of demand were conducted.

Each section contains a detailed summary and only selected highlights are reiterated below:

(1) previous studies have indicated an important shift in the composition of wheat importers. Traditional importers or regions such as Japan or Western Europe have declined in relative importance. This decline is expected to continue as imports by developing countries are expected to comprise a greater proportion of world trade. The results of this study confirm that growth potential was greater for developing countries. Africa and the Middle East for example had historic growth rates in excess of 8 percent compared to 3 percent in Japan and 4 percent in the World. Of particular importance is that the traditional importers consume wheat largely in the form of traditional bread products. The increasing importance of developing countries as wheat importers is important for two reasons. First, their ability to pay is lower than traditional importers. Second, consumption patterns in many of these countries differ and consequently the characteristics of wheat demanded may differ from traditional exporters. It is of interest that in the past 20 years the fastest growth rates in trade were those for SRW and EC, both soft wheats, and HRS which is a strong wheat. The slowest growth was that of HRW, a traditional, medium protein wheat.

(2) Relative prices are particularly important in demand analysis. Review of international wheat prices indicates that price differences have increased substantially since the early 1970s, a period of little differentiation by wheat class. Of particular interest is that both HRS and CWRS prices have increased relative to others, but increases in CWRS have exceeded those of HRS. Embedded in these prices are implicit values for quality characteristics which can be estimated and interpreted directly by holding other factors constant. The analysis of implicit values indicates that (a) there are significant premiums for Canadian wheats (or discounts for U.S. wheats); (b) there are significant implicit values for spring planted wheat versus winter; and (c) the implicit value of protein has been increasing throughout the 1980s.

(3) Wheat import shares are determined partly by macro influences such as income and the level of domestic wheat production. Countries with high incomes tend to use a greater proportion of wheat for feed. Lower income countries tend to import more HRW and SRW. Countries with larger production tend to import porportionately less of the medium protein wheats, HRW and ARG, and more of CWRS.

(4) There are several important conclusions from the time series demand analysis. First, there are unique underlying demands and preferences for wheats of different classes and origins. Of particular interest is that preferences for HRW and HRS are distinctly different in all markets. In addition, there is a significant difference in preferences for HRS and CWRS.

Second, there are several quality factors in the U.S. which have varied through time and which have impacted the distribution of market shares. Most notable are the negative impacts of declining protein levels in HRS, and adverse impacts of sprout damage in spring wheat on HRS exports. Third, a number of demand factors can be used to explain the variability in class market shares through time. These include relative prices, income, tastes and preferences, technology, and the level of domestic production. Of the markets analyzed, Asia was the most price responsive, the least being Latin America and the Middle East. The impacts of the other variables on import shares are difficult to discern due to the high degree of multi-collinearity between them. However, the results did indicate significant nonprice shifts in underlying functions.

The methodology which was used allowed for measurement and comparisons of underlying nonprice shifts in preferences occurring through time. Several shifts of particular interest include: (1) increases in SRW, HRS and CWRS in Asia; (2) increase in SRW and durum in Africa, and decreases in HRW; (3) decreases in HRW in the Middle East; (4) decreases in SRW in Latin America and increases in HRW and spring wheats. In general the World market is experiencing nonprice shifts in preferences away from HRW and increases in soft wheats, SRW and EC, and in HRS.

Numerous changes in market shares of wheat classes are expected in specific markets, and in some cases these are relatively large. In general these changes reflect the shifts in preferences discussed above. However, despite the shift in preferences toward HRS, growth in this market will be stalled due to the current high price for this class relative to others.

In general the results indicate that quality differentials are important in international markets, having impacts on both relative prices and shares in particular markets. Being there are unique demands for different classes of wheat, and given the important underlying shifts in imports, the ability to differentiate wheats of different classes is a very important component of international competition. A particular concern, however, is that in many markets the preferences for U.S. wheats are distinctly different from like wheats of competitors. In some markets there is a tendency for imports to shift toward stronger wheats as income increases. However, this is not generally true and in fact in some cases increased incomes through time result in increased imports of softer wheats. Thus, strong wheats are not necessarily luxury, and softer wheats are not necessarily inferior goods. Some markets are highly price responsive but a number are very quality conscious. Some quality conscious markets tend to have a preference for strong wheats, while others have strong preferences for typically cheaper wheats. In the latter case, unique preferences exist for particular wheat qualities and consequently shares are very unresponsive to changes in relative prices. Generally, however, relative prices are important in nearly all markets. Indeed, despite some strong wheats being increasingly preferred, they currently have relatively high prices thereby precluding growth in shares.

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Appendix A

Statistical Tables

TABLE A1. U.S. WHEAT EXPORT PRICES (FOB), 1960/61-1985/86

Year[1]	FOB Gulf No. 2 Dark Northern Spring 14%	FOB Gulf No. 2 Hard Red Winter 13%	FOB Gulf No. 2 Hard Red Winter Ord.	FOB Atlantic No. 2 Soft Red Winter	FOB Pacific No. 2 Dark Northern Spring 14%	FOB Pacific No. 2 Western White	FOB Pacific No. 2 Hard Red Winter Ord.
				U.S. $/MT			
1960	--	--	62	59	--	--	62
1961	--	68	63	60	--	60	64
1962	71	65	64	59	67	61	62
1963	68	67	66	64	--	64	64
1964	67	65	64	60	65	59	61
1965	64	60	60	59	64	59	56
1966	68	67	67	65	69	63	67
1967	66	63	62	57	66	59	61
1968	67	63	63	59	65	60	62
1969	62	57	53	54	61	55	56
1970	67	63	60	62	64	59	58
1971	66	62	60	60	63	59	58
1972	91	92	91	89	93	93	91
1973	184	178	177	--	190	186	184
1974	192	170	164	159	199	165	166
1975	176	161	152	140	185	146	150
1976	133	118	113	109	136	114	114
1977	128	117	116	110	129	119	117
1978	148	142	141	140	151	143	140
1979	183	174	174	168	186	160	173
1980	200	183	182	175	210	167	182
1981	181	173	171	148	184	158	166
1982	173	166	159	132	174	165	163
1983	174	165	154	143	178	148	154
1984	166	152	148	141	170	141	152
1985	155	141	131	123	162	136	137

[1] Trade year beginning July of year indicated.

SOURCE: International Wheat Council, *World Wheat Statistics*, various issues.

TABLE A2. WHEAT IMPORT PRICES CIF ROTTERDAM, 1960/61-1984/85

	Canada	United States			
Year[1]	No. 1 Canada Western Red Spring	No. 2 Dark Northern Spring 14%	No. 2 Hard Red Winter 13.5%	No. 2 Hard Red Winter Ord.	No. 2 Soft Red Winter
	U.S. $/MT				
1960[1]	73	--	--	68	64
1961	76	--	--	70	65
1962	76	75	--	71	62
1963	78	75	74	72	68
1964	77	74	71	70	65
1965	78	71	67	65	64
1966	80	76	72	71	69
1967	76	70	69	68	63
1968	73	70	69	68	64
1969	72	69	67	63	60
1970	74	74	71	69	66
1971	72	70	67	66	63
1972	102	100	92	98	64
1973	224	202	194	193	--
1974	207	204	190	157	--
1975	206	188	177	159	144
1976	146	141	136	121	117
1977	147	134	137	127	120
1978	166	158	158	154	155
1979	216	200	205	191	191
1980	249	218	217	202	203
1981	214	193	199	183	169
1982	194	180	188	--	151
1983	208	186	--	--	159
1984	188	178	--	--	146

[1] Trade year beginning July of year indicated.

SOURCE: International Wheat Council, World Wheat Statistics, various issues.

TABLE A3. WHEAT IMPORT PRICES CIF JAPAN, 1960/61-1985/86

	Australia		Canada	United States			
Year[1]	Prime Hard 13%	ASW	No. 1 Canada Western Red Spring 13.5%	No. 2 Dark Northern Spring 14%	No. 2 Hard Red Winter 13%	No. 2 Hard Red Winter Ordinary	No. 2 Western White
	-----------	-----------	-----------	U.S. $/MT	-----------	-----------	-----------
1960	--	69	--	--	--	75	71
1961	--	--	83	--	--	80	73
1962	--	72	82	--	--	78	73
1963	--	77	84	--	--	80	78
1964	--	73	85	79	79	76	74
1965	76	67	77	71	71	65	68
1966	75	70	81	76	75	74	71
1967	73	67	78	75	73	69	67
1968	71	66	76	73	71	68	66
1969	67	62	73	70	68	65	63
1970	--	68	76	73	73	68	69
1971	67	64	72	70	69	65	65
1972	85	85	105	98	100	99	99
1973	236	232	224	213	220	223	215
1974	208	183	223	215	206	192	187
1975	189	159	204	200	185	168	162
1976	141	126	154	148	140	128	125
1977	135	127	147	138	131	125	129
1978	172	162	179	168	166	154	159
1979	217	204	234	220	216	207	194
1980	235	216	264	243	230	220	201
1981	215	202	234	215	213	203	191
1982	209	196	225	211	215	201	202
1983	210	187	227	213	212	189	182
1984	183	174	212	196	188	177	167
1985	183	163	208	193	182	167	167

[1] Trade year beginning July of year indicated.

SOURCE: International Wheat Council, World Wheat Statistics, various issues.

TABLE A4. SELECTED U.S. WHEAT EXPORT PRICES RELATIVE TO HARD RED WINTER ORDINARY PROTEIN,[1] 1960/61-1985/86

	U.S. Gulf			Pacific	
Year[2]	Dark Northern Spring 14%	Hard Red Winter 13%	Atlantic Soft Red Winter	Dark Northern Spring 14%	Western White
1960	--	--	0.95	--	--
1961	--	1.08	0.95	--	0.93
1962	1.11	1.02	0.92	1.08	0.98
1963	1.03	1.02	0.97	--	1.00
1964	1.05	1.02	0.94	1.07	0.97
1965	1.07	1.00	0.98	1.14	1.05
1966	1.01	1.00	0.97	1.03	0.94
1967	1.06	1.02	0.92	1.08	0.97
1968	1.06	1.00	0.94	1.05	0.97
1969	1.17	1.08	1.02	1.09	0.98
1970	1.12	1.05	1.03	1.10	1.02
1971	1.10	1.03	1.00	1.08	1.02
1972	1.00	1.01	0.98	1.02	1.02
1973	1.04	1.01	--	1.03	1.01
1974	1.07	1.04	0.97	1.20	0.99
1975	1.16	1.06	0.92	1.23	0.97
1976	1.17	1.04	0.96	1.19	1.00
1977	1.10	1.00	0.94	1.10	1.02
1978	1.05	1.01	0.99	1.08	1.02
1979	1.05	1.00	0.96	1.08	0.92
1980	1.10	1.01	0.96	1.15	0.92
1981	1.06	1.01	0.87	1.11	0.95
1982	1.09	1.04	0.83	1.07	1.01
1983	1.13	1.07	0.93	1.16	0.96
1984	1.12	1.03	0.95	1.12	0.93
1985	1.18	1.07	0.94	1.18	0.99

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[1] Each price was divided by that of U.S. hard red winter ordinary to derive the reported price ratio.

[2] Trade year beginning July of year indicated.

SOURCE: International Wheat Council, World Wheat Statistics, various issues.

TABLE A5. SELECTED CIF ROTTERDAM PRICES RELATIVE TO HRW ORDINARY PROTEIN, 1960/61-1985/86

Year[1]	Canadian Western Red Spring	U.S. Dark Northern Spring 14%	U.S. Hard Red Winter 13.5%	U.S. Soft Red Winter
1960	1.07	--	--	0.94
1961	1.09	--	--	0.93
1962	1.07	1.06	--	0.87
1963	1.08	1.04	1.03	0.94
1964	1.10	1.06	1.01	0.93
1965	1.20	1.09	1.03	0.98
1966	1.13	1.07	1.01	0.97
1967	1.12	1.04	1.01	0.93
1968	1.07	1.03	1.01	0.94
1969	1.14	1.10	1.06	0.95
1970	1.07	1.07	1.03	0.96
1971	1.09	1.06	1.02	0.95
1972	1.04	1.02	0.93	0.65
1973	1.16	1.05	1.01	--
1974	1.32	1.30	1.21	--
1975	1.30	1.18	1.11	0.91
1976	1.21	1.17	1.12	0.97
1977	1.16	1.06	1.08	0.94
1978	1.08	1.03	1.03	1.01
1979	1.13	1.05	1.07	1.00
1980	1.23	1.08	1.07	1.00
1981	1.17	1.05	1.08	0.92
1982	--	--	--	--
1983	--	--	--	--
1984	--	--	--	--

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[1] Each price was divided by that of U.S. hard red winter ordinary to derive the reported price ratio.

[2] Trade year beginning July of year indicated.

SOURCE: International Wheat Council, World Wheat Statistics, various issues.

TABLE A6. SELECTED CIF JAPAN PRICES RELATIVE TO HARD RED WINTER ORDINARY, 1960/61-1985/86

	Australia		Canada	United States		
Year[1]	Australian Soft Winter	Prime Hard 13%	Canadian Western Red Spring	Dark Northern Spring 14%	Western White	Hard Red Winter 13%
1960	0.92	--	--	--	0.95	--
1961	--	--	1.04	--	0.91	--
1962	0.92	--	1.05	--	0.94	--
1963	0.96	--	1.05	--	0.98	--
1964	0.96	--	1.12	1.04	0.97	1.04
1965	1.03	1.17	1.18	1.09	1.05	1.10
1966	0.95	1.01	1.10	1.02	0.96	1.01
1967	0.97	1.06	1.13	1.09	0.97	1.06
1968	0.97	1.04	1.12	1.07	0.97	1.04
1969	0.95	1.03	1.12	1.08	0.97	1.05
1970	1.00	--	1.12	1.07	1.01	1.07
1971	0.98	1.03	1.11	1.08	1.00	1.06
1972	0.86	0.86	1.06	0.99	1.00	1.01
1973	1.04	1.06	1.00	0.96	0.96	0.99
1974	0.95	1.08	1.16	1.12	0.97	1.07
1975	0.95	1.13	1.21	1.19	0.96	1.10
1976	0.98	1.10	1.20	1.16	0.98	1.09
1977	1.02	1.08	1.18	1.10	1.03	1.05
1978	1.05	1.12	1.16	1.09	1.03	1.08
1979	0.99	1.05	1.13	1.06	0.94	1.04
1980	0.98	1.07	1.20	1.10	0.91	1.05
1981	0.99	1.06	1.15	1.06	0.94	1.05
1982	0.98	1.04	1.12	1.05	1.00	1.07
1983	0.99	1.11	1.20	1.13	0.96	1.12
1984	0.98	1.03	1.20	1.11	0.94	1.06
1985	0.98	1.10	1.25	1.16	1.00	1.09

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[1] Each price was divided by that of U.S. hard red winter ordinary to derive the reported price ratio.

[2] Trade year beginning July of year indicated.

SOURCE: International Wheat Council, _World Wheat Statistics_, various issues.

TABLE A7. COUNTRIES INCLUDED IN THE AFRICA REGION

Algeria
Angola
Benin
Botswana
Burkina Faso
Burundi
Cameroon
Cape Verde
C. African Rep.
Chad
Comoros
Congo
Cote d'Ivoire
Djibouti
Equatorial Guinea
Ethiopia
Gabon
Gambia, The
Ghana
Guinea
Guinea-Bissau
Kenya
Lesotho
Liberia
Madagascar
Malawi
Mali
Mauritania
Mauritius
Morocco
Mozambique
Niger
Nigeria
Reunion
Rwanda
St. Helena
Sao Tome & Principe
Senegal
Seychelles
Sierre Leone
Somalia
South Africa
Sudan
Swaziland
Tanzania
Togo
Tunisia
Uganda
Zaire
Zambia
Zimbabwe

TABLE A8. COUNTRIES INCLUDED IN THE ASIA REGION

Afghanistan
American Samoa
Bangladesh
Bhutan
Brunei
Burma
China, People's Rep.
Fiji
French Polynesia
Guam
Hong Kong
India
Indonesia
Kampuchea, Dem.
Kuribati
Korea
Lao P. D. Rep.
Macao
Malaysia
Maldives
Nauru
Nepal
New Caledonia
Pakistan
Papua New Guinea
Philippines
Singapore
Solomon Islands
Sri Lanka
Thailand
Tonga
Vanuatu
Viet Nam
Western Samoa

TABLE A10. COUNTRIES INCLUDED IN THE MIDDLE EAST REGION

Bahrain
Egypt
Iran, I.R. of
Iraq
Israel
Jordan
Kuwait
Lebanon
Libya
Oman
Qatar
Saudi Arabia
Syrian Arab Rep.
United Arab Emirates
Yemen Arab Rep.
Yemen P. D. Rep.

TABLE A11. AVERAGE ANNUAL GROWTH RATES OF Selected VARIABLES BY MARKET, 1961/62-1984/85

Market	Real Income Per Capita	Population	Domestic Production	Concessional Imports	Total Imports	Domestic Consumption
Africa	3.2	0.5	2.6	-3.2	8.9	
Asia	2.6	2.3	6.0	-13.7	2.4	
Latin America	4.5	0.4	3.6	-7.7	5.1	
Middle East	3.3	2.9	2.9	4.0	9.5	
Japan	6.1	1.0	-4.2		3.3	
United States	2.2					2.1
World	1.8	2.0	3.3	-5.8	4.0	

[1] Derived from a simple regression of log $X_i = \gamma + \beta T$ using autoregression techniques. X_i is the value of the macro-economic variables, T is time trend, β is the growth rate and the reported coefficient.

TABLE A12. CORRELATION COEFFICIENTS BETWEEN SELECTED VARIABLES BY MARKET, 1961/62-1984/85

		Variables				
Market	Variable	Trend	Real Income Per Capita	Production	Concessional Imports	Total Imports
Africa	T	1.00	.97	.73	-.04	.92
	YC	.97	1.00	.76	-.16	.83
	Prod	.73	.76	1.00	-.37	.48
	Con	-.04	-.16	-.37	1.00	.20
	Imp	.92	.83	.48	.20	1.00
Asia	T	1.00	.97	.97	-.84	.68
	YC	1.00	1.00	.98	-.79	.70
	Prod	.97	.98	1.00	-.81	.65
	Con	-.84	-.79	-.81	1.00	-.39
	Imp	.68	.70	.65	-.39	1.00
Latin America	T	1.00	.99	.87	-.73	.94
	YC	.99	1.00	.86	-.73	.95
	Prod	.87	.86	1.00	-.64	.73
	Con	-.73	-.73	-.64	1.00	-.61
	Imp	.94	.95	.73	-.61	1.00
Middle East	T	1.00	.94	.91	.40	.96
	YC	.94	1.00	.89	.34	.86
	Prod	.91	.89	1.00	.39	.84
	Con	.40	.34	.39	1.00	.56
	Imp	.96	.86	.84	.56	1.00

TABLE A13. CORRELATION COEFFICIENTS BETWEEN SELECTED VARIABLES BY MARKET, 1961/62-1984/85

		Variables				
Market	Variable	Trend	Real Income Per Capita	Production	Concessional Imports	Total Imports
Japan	T	1.00	.99	-.62		
	YC	.99	1.00	-.70		
	Prod	-.62	-.70	1.00		
United States	T	1.00	.98			.83
	YC	.98	1.00			.78
	Imp	.83	.78			1.00
	Prow	-.02	.03			-.22
World	T	1.00	.96	.98	-.71	.87
	YC	.96	1.00	.93	-.76	.75
	Prod	.98	.93	1.00	-.69	.85
	Con	-.71	-.76	-.69	1.00	-.45
	Imp	.87	.75	.85	-.45	1.00

Appendix B

Specification Searches Using Log-Linear Case Functions

For each country, region, and the world, a log-linear Case function market share model was estimated with the general form:

$$\ln (S_{jt}/S_{1t}) = \beta_0 + \beta_1 \ln X_t + \gamma \ln (P_{1t}/P_{jt}) + e_t$$

for j = 2 . . . N imported wheat classes

with γ constrained to be identical across equations

where S_j is the market share of the j^{th} wheat class

X is any shift variable

P_j is the representative price of the j^{th} wheat class

The basic purpose of estimating the linear market share models was to test hypotheses about the effects of shift variables on relative market shares. The shift variables tested included the macro variables, trend, real income per capita, per capita domestic production, and concessional imports. The trend variable was used to determine shifts in consumption patterns based on changes in tastes and preferences. Due to the high levels of correlation between theese variables, usually only one of them could be included in an equation at a time. Other shift variables tested in the models were the average protein level of the U.S. HRW crop and the average falling number count of the U.S. HRS crop, two nongrade quality factors. A dock strike variable, following Gallagher et al., was also included in some models. This captured the effects of lengthy U.S. West Coast dock strikes on relative market shares.

Models were estimated in the following fashion. First, several models were estimated for each market, each including a single shift variable. Variables which proved significant were successively added together into models to determine the "best" model. The price ratio was included in all models and its value constrained to equality across all equations in a model.

The same wheat class was used, in all equations of each market's models, as the market share denominator (S_1) and price numerator (P_1). The class chosen for the denominator was generally that which has been dominant. All models were estimated using seemingly unrelated regression.

Contained in the Tables B1-B70 are the estimation results of selected linear models. The model containing relative prices and trend was retained for each market along with the one or two other models which seemed to provide logical results. Table B1 contains a listing of the variables included in chosen models by market.

TABLE B1. SHIFT VARIABLES INCLUDED IN ESTIMATED, LINEAR MARKET SHARE MODELS CHOSEN FOR EACH MARKET

Market	Variables
Africa	T; T, Prod; YC Prod
Asia	T; T, Dstrike
Latin America	T; T, Con, Prow, FN
Middle East	T; T, Con
Japan	T; T, FN, Dstrike
United States	T; T, Prow
World	T; T, Prow, FN

NOTE: T is trend, Prod is per capita domestic production, YC is per capita real income, Dstrike is West Coast (U.S.) dockstrikes, Con is concessional imports, Prow is U.S. HRW crop average protein, FN is U.S. HRS crop average falling number (an indicator of sprout damage).

Examination of results from model estimation (Tables B1-B7) reveals some general insights. In each market relative market shares are price responsive as indicated by the value of the price ratio coefficient except in the Middle East. Asia is the market with the greatest price responsiveness, by far. Most of the intercept terms are significant with many substantially different from each other, suggesting that different preference structures exist for individual wheat classes. Trend coefficients are also generally significant indicating that shifts in preferences are occurring. The interpretation of the cause for these shifts becomes fuzzy, however, due to the high degrees of correlation between the macro variables. These variables are mostly trending variables (e.g., income) in either direction, thus rendering it difficult at best to separate out the effects of individual variables on relative market shares. As a general rule also, models for the same market which included trend or income had similar results.

Thus, if there are nonprice shifts occurring in relative market shares, (i.e., shifts in relative shares caused by factors other than prices), it is not possible from these results to attribute it to changes in tastes and preferences as indicated by trend, or income shifts. Only in the case of Africa was the impact of income notably different from that of trend. In that case, increases (decreases) in income result in significant reductions (increases) in CWRS and increases (decreases) in durums, both U.S. and Canadian. Similarly, increases in domestic production in that region result in reduced imports of SRW and increased Canadian durum.

Model results differed between markets, and a few of the more interesting results are noted here. In the Latin American models many of the coefficients estimated for the quality variables (protein and falling numbers) were significant when these variables were added to the basic model with relative prices and trend. That the coefficients are significant suggests that these quality factors do influence relative market shares and cause shifts between classes of wheat imports. Results from the Middle East models reveal that prices are not significant variables for explaining variability in relative market shares. The fact that the intercept coefficients are significant and have differing values does suggest that strong preferences for certain classes exist, or that a definite and rigid preference structure exists. Model results for Japan are interesting from the perspective that the inclusion of the dock strike variable significantly increased model performance. This was not true for any other market. The incidence of dock strikes resulted in shifts toward all other wheat types except HRS, from U.S. White.

There are several results of interest in the world market. First, as indicated by the differences in intercepts, there is a preference for CWRS relative to HRW, compared to HRS relative to HRW, even though CWRS and HRS are often thought to be technically similar and/or grouped. Through time there have been significant nonprice shifts toward SRW, EC, and HRS relative to HRW. However, in the model which includes crop average protein in HRW and HRS falling numbers, the results change. Higher values of falling numbers, indicating reduced incidence of sprout damage results in HRS and WHI gaining relative to HRW, and Argentine losing relative to HRW. Of particular interest is that by including these two quality variables in the demand model, several non-neutral trends discussed above disappear. The interpretation here, though tentative is that U.S. HRW protein, itself a negative trending variable, may account for some of the nonprice shifts away from HRW. This is indicated by the negative coefficients associated with HRW protein in the EC and HRS equations. However, the nonprice gain of SRW relative to HRW is still present.

TABLE B2. CASE FUNCTION LINEAR MODEL ESTIMATES FOR AFRICA IMPORTED WHEAT CLASS MARKET SHARES, 1961/62-1984/85

Equation	Parameters					System R^2
	INT	P_{EC}/P_1	Trend	Production	Income	
SRW/EC	-1.90* (-2.32)[a]	0.72* (2.23)	0.02 (0.07)			.71
HRW/EC	0.55 (1.21)		-0.45* (-2.45)			
CWRS/EC	-0.10 (-0.22)		-0.65* (-3.61)			
DUR/EC	-6.26* (-4.68)		1.84* (3.42)			
CAD/EC	-10.24* (-8.79)		3.09* (6.63)			
SRW/EC	-0.52 (-0.44)	0.68* (2.04)	0.42 (1.04)	-2.44 (-1.58)		.77
HRW/EC	0.40 (0.58)		-0.48* (-2.06)	0.25 (0.27)		
CWRS/EC	-0.50 (-0.72)		-0.76* (-3.28)	0.70 (0.77)		
DUR/EC	-6.15* (-2.99)		1.87* 2.67	-0.19 (-0.07)		
CAD/EC	-13.5* (-9.53)		2.18* (4.56)	5.72* (3.11)		
SRW/EC	5.35 (1.15)	0.86* (2.53)	1.34 (1.28)	-2.74* (-1.79)	1.34 (1.28)	.74
HRW/EC	-4.16 (-1.45)		-1.06 (-0.01)	-0.01 (-0.01)	-1.06 (-.01)	
CWRS/EC	-9.15* (-3.40)		-2.00* (-3.30)	0.65 (0.73)	-2.00 (-3.30)	
DUR/EC	8.35 (0.92)		3.29 (1.60)	1.17 (0.39)	3.29 (1.60)	
CAD/EC	10.28* (1.72)		5.44* (4.03)	5.88* (2.99)	5.44 (4.03)	

[a] T-ratio in parentheses.

*Indicates significance at the 10 percent level.

TABLE B3. CASE FUNCTION LINEAR MODEL ESTIMATES FOR ASIA IMPORTED WHEAT CLASS MARKET SHARES, 1961/62-1984/85

	Parameters				
Equation	INT	P_{ASW}/P_1	Trend	Dock Strike	System R^2
WHI/ASW	-0.55*	4.92*	0.07		.44
	(-2.38)[a]	(4.88)	(0.77)		
SRW/ASW	-9.26*		2.82*		
	(-8.14)		(5.99)		
HRW/ASW	0.76*		-0.40*		
	(1.93)		(-2.46)		
HRS/ASW	-2.83*		0.79*		
	(-7.77)		(5.55)		
CWRS/ASW	0.08		0.31*		
	(0.24)		(2.23)		
WHI/ASW	-0.55*	4.85*	0.08	0.03	.47
	(-2.35)	(4.72)	(0.78)	(0.26)	
SRW/ASW	-9.28*		2.83*	0.24	
	(-8.00)		(5.90)	(0.44)	
HRW/ASW	0.74*		-0.39*	0.12	
	(1.89)		(-2.42)	(0.65)	
HRS/ASW	-2.82*		0.78*	-0.21	
	(-7.75)		(5.50)	(-1.34)	
CWRS/ASW	0.07		0.31*	0.06	
	(0.20)		(2.19)	(0.42)	

TABLE B4. CASE FUNCTION LINEAR MODEL ESTIMATES FOR LATIN AMERICA IMPORTED WHEAT CLASS MARKET SHARES, 1961/62-1984/85

	Parameters							
Equation	INT	P_{HRW}/P_i	Trend	Production	Concessional Imports	U.S. HRW Average Protein	U.S. HRS Av. Falling Numbers	System R^2
EC/HRW	-2.08*	0.93*	-0.24*					.58
	(-6.47)[a]	(4.06)	(-1.84)					
WHI/HRW	-2.57*		-0.70*					
	(-3.65)		(-2.46)					
ARG/HRW	0.70		-0.73*					
	(1.31)		(-3.40)					
SRW/HRW	-2.25*		-0.14					
	(-4.48)		(-0.67)					
HRS/HRW	-1.87*		0.24*					
	(-5.75)		(1.89)					
CWRS/HRW	-1.48*		0.15					
	(-4.82)		(1.19)					
DUR/HRW	-6.24*		1.13*					
	(-13.32)		(5.98)					
EC/HRW	-6.86	0.80*	-1.04*		-0.12	1.55	0.61*	.76
	(-1.44)	(2.97)	(-3.59)		(-0.87)	(0.88)	(1.85)	
WHI/HRW	-7.81		-0.47		0.72*	1.23	-0.39	
	(-0.76)		(-0.76)		(2.66)	(0.32)	(0.55)	
ARG/HRW	6.21		-1.70*		-0.06	-2.66	0.66	
	(0.68)		(-3.09)		(-0.25)	(-0.79)	(1.04)	
SRW/HRW	-12.34*		-1.39*		-0.16	4.80*	0.36	
	(- 1.89)		(-3.55)		(-0.91)	(1.99)	(0.81)	
HRS/HRW	3.04		-0.53*		-0.03	-2.83*	0.72*	
	(1.12)		(-3.28)		(-0.47)	(-2.82)	(3.88)	
CWRS/HRW	9.87*		0.22		-0.17	-3.74*	-0.24	
	(2.02)		(0.76)		(-1.33)	(-2.07)	(-0.71)	
DUR/HRW	- 8.54		-0.04		-0.15	1.02	0.61	
	(- 1.33)		(-0.09)		(-0.87)	(0.43)	(1.37)	

[a] T-ratio in parentheses.

*Indicates significance at 10 percent level.

TABLE B5. CASE FUNCTION LINEAR MODEL ESTIMATES FOR MIDDLE EAST IMPORTED WHEAT CLASS MARKET SHARES, 1961/62-1984/85

Equation	Parameters				System R^2
	INT	P_{ASW}/P_i	Trend	Concessional Imports	
EC/ASW	0.08	0.07	-0.02		.42
	(0.16)	(0.13)	(-0.12)		
SRW/ASW	-1.25		-0.31		
	(-1.63)		(-0.97)		
WHI/ASW	-2.57*		0.28		
	(-2.96)		(0.80)		
HRW/ASW	1.53*		-0.83*		
	(5.40)		(-7.16)		
CWRS/ASW	-1.95*		0.14		
	(-4.85)		(0.87)		
EC/ASW	2.40*	0.23	0.06	-0.38*	.48
	(2.22)	(0.50)	(0.35)	(-2.41)	
SRW/ASW	-3.84*		-0.34	0.41	
	(-2.06)		(-1.06)	(1.51)	
WHI/ASW	-6.06*		0.21	0.56*	
	(-2.88)		(0.58)	(1.81)	
HRW/ASW	1.52*		-0.83*	0.00	
	(2.09)		(-6.59)	(0.02)	
CWRS/ASW	-2.48*		0.12	0.09	
	(-2.49)		(0.65)	(0.64)	

[a] T-ratio in parentheses.

*Indicates significance at 10 percent level.

TABLE B6. CASE FUNCTION LINEAR MODEL ESTIMATES FOR JAPAN IMPORTED WHEAT CLASS MARKET SHARES, 1961/62-1984/85

	Parameters					
Equation	INT	$\bar{P}_{WHI}/P_i$	Trend	U.S. HRS Avg. Falling Numbers	Dock Strike	System R^2
ASW/WHI	-0.70	0.55	0.22			.35
	(-1.48)	(1.25)	(1.22)			
HRW/WHI	0.48*		-0.09			
	(3.11)		(-1.54)			
HRS/WHI	-5.20*		1.77*			
	(-4.52)		(3.97)			
CWRS/WHI	1.02*		-0.25*			
	(5.01)		(-3.05)			
ASW/WHI	-2.19	0.61*	0.07	0.32	0.36*	.63
	(-1.44)	(1.77)	(0.42)	(1.20)	(3.89)	
HRW/WHI	0.41		-0.15*	0.04	0.12*	
	(0.77)		(-2.61)	(0.39)	(3.77)	
HRS/WHI	-4.33*		0.65*	0.37	0.08	
	(-3.29)		(4.66)	(1.62)	(1.01)	
CWRS/WHI	1.77*		-0.24*	-0.13	0.19*	
	(2.62)		(-3.23)	(-1.07)	(4.54)	

TABLE B7. CASE FUNCTION LINEAR MODEL ESTIMATES FOR UNITED STATES DOMESTIC WHEAT CONSUMPTION SHARES BY CLASS, 1961/62-1984/85

	Parameters				System
Equation	INT	P_{HRW}/P_i	Trend	Protein on U.S. HRS	R^2
SRW/HRW	-0.67*	0.98*	-0.06*		.34
	(-9.09)[a]	(5.79)	(-1.92)		
WHI/HRW	- 1.79*		0.03		
	(-14.20)		(0.54)		
HRS/HRW	- 0.46*		-0.10*		
	(- 3.87)		(-2.23)		
DUR/HRW	- 2.18*		0.09		
	(-14.24)		(1.46)		
SRW/HRW	3.80*	0.77*	-0.03	-1.83	.42
	(2.90)	(4.14)	(-0.58)	(-3.50)	
WHI/HRW	3.88*		-0.24*	-2.00*	
	(2.40)		(-3.38)	(-3.09)	
HRS/HRW	2.76		-0.03	-1.38	
	(1.24)		(-0.29)	(-1.56)	
DUR/HRW	- 3.21		0.14	0.37	
	(- 1.24)		(1.21)	(0.36)	

[a] T-ratio in parentheses.

*Indicates significance at 10 percent level.

TABLE B8. CASE FUNCTION LINEAR MODEL ESTIMATES FOR WORLD IMPORTED WHEAT CLASS MARKET SHARES, 1961/62-1984/85

	Parameters					System
Equation	INT	P_{HRW}/P_i	Trend	U.S. HRW Average Protein	U.S. HRS Average Falling #s	R^2
SRW/HRW	-2.55* (-6.68)	1.21* (8.28)	0.37* (2.38)			.63
WHI/HRW	-1.30* (-8.16)		0.06 (0.98)			
EC/HRW	-1.19* (-6.98)		0.27* (3.82)			
ASW/HRW	-0.63* (-3.48)		0.07 (0.93)			
ARG/HRW	-1.51* (-4.98)		0.05 (0.36)			
HRS/HRW	-2.56* (-11.65)		0.57* (6.11)			
CWRS/HRW	0.27* (1.73)		-0.01 (-0.14)			
SRW/HRW	-20.52* (- 2.91)	1.26* (8.47)	0.88* (2.93)	7.60* (2.92)	-0.37 (-0.73)	.75
WHI/HRW	- 7.44* (- 2.33)		-0.08 (-0.62)	1.63 (1.38)	0.42* (1.85)	
EC/HRW	0.79 (0.21)		0.15 (0.95)	-0.79 (-0.56)	0.05 (0.17)	
ASW/HRW	- 5.73 (- 1.43)		-0.08 (-0.46)	1.50 (1.01)	0.30 (1.05)	
ARG/HRW	3.90 (0.61)		0.17 (0.61)	-0.44 (-0.19)	-0.78* (-1.71)	
HRS/HRW	- 1.96 (- 0.90)		0.07 (0.75)	-0.73 (-0.91)	0.42* (2.70)	
CWRS/HRW	0.14 (0.04)		-0.19 (-1.33)	0.27 (0.22)	-0.01 (-0.04)	

[a] T-ratios in parentheses.

*Indicates significance at 10 percent level.

Appendix C

Market Share Elasticities, Class Preference Parameters, and Simulated Market Shares

TABLE C1. MARKET SHARE PRICE ELASTICITIES FOR IMPORTED WHEAT CLASSES IN AFRICA, 1984/85

	European Community	Soft Red Winter	Hard Red Winter	Canadian Western Red Spring	Durum	Canadian Durum
European Community	-0.25	0.09	0.07	0.02	0.05	0.02
Soft Red Winter	0.22	-0.38				
Hard Red Winter			-0.41			
Canadian Western Red Spring				-0.45		
Durum					-0.43	
Canadian Durum						-0.46

TABLE C2. MARKET SHARE PRICE ELASTICITIES FOR IMPORTED WHEAT CLASSES ASIA, 1984/85

	Australian Standard White	White	Soft Red White	Hard Red White	Hard Red Spring	Canadian Western Red Spring
Australian Standard White	-3.97	1.06	1.01	0.40	0.42	1.07
White	1.58	-4.49				
Soft Red White			-4.54			
Hard Red White				-5.15		
Hard Red Spring					-5.13	1.07
Canadian Western Red Spring						-4.48

TABLE C3. MARKET SHARE PRICE ELASTICITIES FOR IMPORTED WHEAT CLASSES LATIN AMERICA, 1984/85

	Hard Red Winter	European Community	White	Argentina	Soft Red Winter	Hard Red Spring	Canadian Western Red Spring	U.S. Durum
Hard Red Winter	-0.45	0.02	0.01	0.11	0.05	0.10	0.14	0.02
European Community	0.42	-0.85						
White			-0.86					
Argentina				-0.76				
Soft Red Winter					-0.83			
Hard Red Spring						-0.77		
Canadian Western Red Spring							-0.74	
U.S. Durum								-0.85

TABLE C4. MARKET SHARE PRICE ELASTICITIES FOR IMPORTED WHEAT CLASSES IN THE MIDDLE EAST, 1984/85

	Australian Standard White	European Community	Soft Red Winter	White	Hard Red Spring	Canadian Western Red Spring
Australian Standard White	-0.04	0.01	0.00	0.01	0.01	0.01
European Community	0.03	-0.05				
Soft Red Winter			-0.06			
White				-0.06		
Hard Red Spring					-0.06	
Canadian Western Red Spring						-0.06

TABLE C5. MARKET SHARE PRICE ELASTICITIES FOR IMPORTED WHEAT CLASSES IN JAPAN, 1984/85

	White	Australian Standard White	Hard Red Winter	Hard Red Spring	Canadian Western Red Spring
White	-0.49	0.11	0.14	0.11	0.14
Australian Standard White	0.10	-0.48			
Hard Red Winter			-0.46		
Hard Red Spring				-0.48	
Canadian Western Red Spring					-0.45

TABLE C6. MARKET SHARE PRICE ELASTICITIES FOR DOMESTICALLY CONSUMED WHEAT CLASSES IN THE UNITED STATES, 1985/86

	Hard Red Winter	Soft Red Winter	White	Hard Red Spring	Durum
Hard Red Winter	-0.59	0.24	0.09	0.21	0.05
Soft Red Winter	0.64	-0.99			
White			-1.14		
Hard Red Spring				-1.02	
Durum					-1.18

TABLE C7. MARKET SHARE PRICE ELASTICITIES FOR IMPORTED WHEAT CLASSES IN THE WORLD, 1984/85

	Hard Red Winter	Soft Red Winter	White	European Community	Australian Standard White	Argentina	Hard Red Spring	Canadian Western Red Spring
Hard Red Winter	-1.03	0.09	0.08	0.23	0.20	0.11	0.06	0.26
Soft Red Winter	0.24	-1.18						
White			-1.20					
European Community				-1.04				
Australian Standard White					-1.07			
Argentina						-1.16		
Hard Red Spring							-1.20	
Canadian Western Red Spring								-1.01

TABLE C8. ESTIMATED WHEAT CLASS PREFERENCE PARAMETERS FOR AFRICA: ACTUAL AND FORECAST FOR 1994/95

Year	C12	C13	C14	C15	C16	C21	C23	C24	C25	C26
1964/65	0.01	1.17	0.18	0.02	0.01	90.94	106.86	16.39	1.50	0.30
1974/75	0.03	0.25	0.06	0.03	0.03	28.77	7.26	1.75	0.77	0.74
1984/85	0.06	0.13	0.04	0.03	0.06	17.54	2.28	0.67	0.58	1.09
1994/95[1]	0.08	0.08	0.03	0.04	0.11	12.74	1.08	0.36	0.48	1.39
	C31	C32	C34	C35	C36	C41	C42	C43	C45	C46
1964/65	0.85	0.01	0.15	0.01	0.01	5.54	0.06	6.52	0.09	0.02
1974/75	3.96	0.14	0.24	0.11	0.10	16.43	0.57	4.14	0.44	0.42
1984/85	7.68	0.43	0.29	0.25	0.48	26.22	1.50	3.41	0.86	1.62
1994/95[1]	11.79	0.92	0.33	0.44	1.29	35.46	2.78	3.01	1.34	3.88
	C51	C52	C53	C54	C56	C61	C62	C63	C64	C65
1964/65	60.52	0.67	71.12	10.91	0.20	299.93	3.29	352.46	54.05	4.96
1974/75	37.31	1.30	9.41	2.27	0.96	38.85	1.35	9.80	2.36	1.04
1984/85	30.29	1.73	3.94	1.15	1.87	16.12	0.92	2.10	0.61	0.53
1994/95[1]	26.48	2.08	2.24	0.75	2.89	9.13	0.71	0.77	0.26	0.34

[1] Forecast.

Key: 1 = EC, 2 = SRW, 3 = HRW, 4 = CWRS, 5 = DUR, 6 = CAD.

TABLE C9. ESTIMATED WHEAT CLASS PREFERENCE PARAMETERS FOR ASIA: ACTUAL AND FORECAST FOR 1994/95

Year	C12	C13	C14	C15	C16	C21	C23	C24	C25	C26
1964/65	0.92	0.49	1.04	0.79	1.11	1.094	0.53	1.139	0.86	1.21
1974/75	0.93	0.78	0.97	0.89	1.20	1.087	0.84	1.045	0.96	1.29
1984/85	0.93	0.95	0.94	0.94	1.24	1.074	1.02	1.007	1.01	1.32
1994/95[1]	0.94	1.08	0.92	0.97	1.26	1.073	1.15	0.98	1.04	1.35
	C31	C32	C34	C35	C36	C41	C42	C43	C45	C46
1964/65	2.03	1.87	2.12	1.61	2.26	0.96	0.88	0.47	0.76	1.07
1974/75	1.28	1.19	1.24	1.15	1.54	1.03	0.96	0.81	0.92	1.24
1984/85	1.05	0.98	0.98	0.99	1.30	1.07	1.00	1.02	1.01	1.32
1994/95[1]	0.93	0.87	0.85	0.90	1.17	1.09	1.02	1.18	1.06	1.38
	C51	C52	C53	C54	C56	C61	C62	C63	C64	C65
1964/65	1.27	1.16	0.62	1.32	1.41	0.90	0.83	0.44	0.94	0.71
1974/75	1.12	1.04	0.87	1.08	1.34	0.84	0.78	0.65	0.81	0.75
1984/85	1.06	0.99	1.01	0.99	1.31	0.81	0.76	0.77	0.76	0.76
1994/95[1]	1.03	0.96	1.11	0.94	1.29	0.79	0.74	0.86	0.73	0.77

[1] Forecast.

Key: 1 = ASW, 2 = WHI, 3 = SRW, 4 = HRW, 5 = HRS, 6 = CWRS.

TABLE C10. ESTIMATED WHEAT CLASS PREFERENCE PARAMETERS FOR LATIN AMERICA: ACTUAL AND FORECAST FOR 1994/95

Year	C12	C13	C14	C15	C16	C17	C18
1964/65	0.07	0.02	0.74	0.08	0.21	0.24	0.01
1974/75	0.05	0.01	0.32	0.06	0.25	0.30	0.03
1984/85	0.04	0.01	0.22	0.05	0.26	0.33	0.04
1994/95[1]	0.04	0.01	0.17	0.05	0.27	0.35	0.06
	C21	C23	C24	C25	C26	C27	C28
1964/65	14.86	0.27	11.04	1.14	3.19	3.52	0.13
1974/75	21.77	0.23	6.88	1.25	5.40	6.47	0.60
1984/85	25.65	0.22	5.62	1.31	6.77	8.41	1.14
1994/95[1]	28.53	0.21	4.93	1.34	7.83	9.96	1.74
	C31	C32	C34	C35	C36	C37	C38
1964/65	54.26	3.65	40.29	4.15	11.66	12.84	0.48
1974/75	93.95	4.32	29.71	5.42	23.30	27.91	2.58
1984/85	1.19	4.64	26.06	6.07	31.40	38.99	5.31
1994/95[1]	1.39	4.86	23.95	6.53	38.07	48.38	8.45
	C41	C42	C43	C45	C46	C47	C48
1964/65	1.35	0.09	0.02	0.10	0.29	0.32	0.01
1974/75	3.16	0.15	0.03	0.18	0.78	0.94	0.09
1984/85	4.57	0.18	0.04	0.23	1.20	1.50	0.20
1994/95[1]	5.79	0.20	0.04	0.27	1.59	2.02	0.35

[1] Forecast.

Key: 1 = HRW, 2 = EC, 3 = WHI, 4 = ARG, 5 = SRW, 6 = HRS, 7 = CWRS, 8 = DUR.

TABLE C11. ESTIMATED WHEAT CLASS PREFERENCE PARAMETERS FOR LATIN AMERICA: ACTUAL AND FORECAST FOR 1994/95 (CONTINUED)

Year	C51	C52	C53	C54	C56	C57	C58
1964/65	13.06	0.88	0.24	9.70	2.81	3.09	0.12
1974/75	17.35	0.80	0.18	5.49	4.30	5.15	0.48
1984/85	19.60	0.76	0.16	4.29	5.17	6.42	0.87
1994/95[1]	21.21	0.74	0.15	3.66	5.83	7.40	1.29
	C61	C62	C63	C64	C65	C67	C68
1964/65	4.65	0.31	0.09	3.46	0.36	1.10	0.04
1974/75	4.03	0.19	0.04	1.27	0.23	1.20	0.11
1984/85	3.79	0.15	0.03	0.83	0.19	1.24	0.17
1994/95[1]	3.64	0.13	0.03	0.63	0.17	1.27	0.22
	C71	C72	C73	C74	C75	C76	C78
1964/65	4.23	0.28	0.08	3.14	0.32	0.91	0.04
1974/75	3.37	0.15	0.04	1.06	0.19	0.83	0.09
1984/85	3.05	0.12	0.03	0.67	0.16	0 .81	0.14
1994/95[1]	2.85	0.10	0.02	0.48	0.14	0.79	0.17

[1] Forecast.

Key: 1 = HRW, 2 = EC, 3 = WHI, 4 = ARG, 5 = SRW, 6 = HRS, 7 = CWRS, 8 = DUR.

TABLE C12. ESTIMATED WHEAT CLASS PREFERENCE PARAMETERS FOR JAPAN: ACTUAL AND FORECAST FOR 1994/95

Year	C12	C13	C14	C15	C21	C23	C24	C25
1964/65	0.62	1.79	0.10	3.19	1.60	2.88	0.16	5.12
1974/75	0.86	1.47	0.49	1.86	1.16	1.71	0.57	2.15
1984/85	1.00	1.35	1.04	1.44	1.00	1.34	1.04	1.44
1994/95[1]	1.11	1.27	1.70	1.22	0.90	1.14	1.53	1.10
	C31	C32	C34	C35	C41	C42	C43	C45
1964/65	0.56	0.35	0.06	1.78	9.97	6.21	17.89	31.82
1974/75	0.68	0.59	0.34	1.26	2.02	1.74	2.98	3.75
1984/85	0.74	0.75	0.77	1.07	0.96	0.97	1.29	1.39
1994/95[1]	0.79	0.88	1.34	0.96	0.59	0.65	0.75	0.72
	C51	C52	C53	C54				
1964/65	0.31	0.20	0.56	0.03				
1974/75	0.54	0.46	0.79	0.27				
1984/85	0.69	0.70	0.93	0.72				
1994/95[1]	0.82	0.91	1.04	1.39				

[1] Forecast.

Key: 1 = WHI, 2 = ASW, 3 = HRW, 4 = HRS, 5 = CWRS.

TABLE C13. ESTIMATED WHEAT CLASS PREFERENCE PARAMETERS FOR UNITED STATES: ACTUAL, AND FORECAST FOR 1994/95

Year	C12	C13	C14	C15	C21	C23	C24	C25
1964/65	0.54	0.25	0.61	0.20	1.86	0.46	1.14	0.36
1974/75	0.51	0.25	0.55	0.21	1.95	0.50	1.08	0.41
1984/85	0.50	0.26	0.53	0.22	2.00	0.52	1.05	0.44
1994/95[1]	0.49	0.26	0.51	0.22	2.03	0.53	1.04	0.45
	C31	C32	C34	C35	C41	C42	C43	C45
1964/65	4.02	2.16	2.46	0.79	1.63	0.88	0.41	0.32
1974/75	3.92	2.01	2.17	0.83	1.81	0.93	0.46	0.38
1984/85	3.88	1.94	2.04	0.85	1.90	0.95	0.49	0.41
1994/95[1]	3.85	1.90	1.96	0.86	1.96	0.97	0.51	0.44
	C51	C52	C53	C54				
1964/65	5.11	2.75	1.27	3.13				
1974/75	4.74	2.43	1.21	2.62				
1984/85	4.58	2.29	1.19	2.41				
1994/95[1]	4.47	2.20	1.16	2.28				

[1] Forecast.

Key: 1 = HRW, 2 = SRW, 3 = WHI, 4 = HRS, 5 = DUR.

TABLE C14. ESTIMATED WHEAT CLASS PREFERENCE PARAMETERS FOR WORLD: ACTUAL, AND FORECAST FOR 1994/95

Year	C12	C13	C14	C15	C16	C17	C18
1964/65	0.16	0.37	0.52	0.65	0.32	0.28	1.20
1974/75	0.33	0.41	0.69	0.72	0.36	0.42	1.22
1984/85	0.45	0.43	0.78	0.75	0.37	0.51	1.23
1994/95[1]	0.56	0.45	0.84	0.77	0.38	0.57	1.24
	C21	C23	C24	C25	C26	C27	C28
1964/65	6.27	2.33	3.23	4.04	2.02	1.73	7.52
1974/75	3.01	1.25	2.07	2.16	1.08	1.28	3.68
1984/85	2.20	0.95	1.71	1.64	0.82	1.12	2.71
1994/95[1]	1.79	0.80	1.51	1.38	0.69	1.03	2.22
	C31	C32	C34	C35	C36	C37	C38
1964/65	2.69	0.43	1.39	1.74	0.87	0.74	3.23
1974/75	2.42	0.80	1.66	1.73	0.86	1.02	2.96
1984/85	2.31	1.05	1.80	1.73	0.86	1.18	2.85
1994/95[1]	2.24	1.25	1.89	1.73	0.86	1.29	2.78
	C41	C42	C43	C45	C46	C47	C48
1964/65	1.94	0.31	0.72	1.25	0.62	0.53	2.33
1974/75	1.46	0.48	0.60	1.04	0.52	0.62	1.78
1984/85	1.29	0.58	0.56	0.96	0.48	0.66	1.58
1994/95[1]	1.19	0.66	0.53	0.91	0.46	0.68	1.47

[1] Forecast.

Key: 1 = HRW, 2 = SRW, 3 = WHI, 4 = EC, 5 = ASW, 6 = ARG, 7 = HRS, 8 = CWRS

TABLE C15. ESTIMATED WHEAT CLASS PREFERENCE PARAMETERS FOR WORLD: ACTUAL, AND FORECAST FOR 1994/95 (CONTINUED)

Year	C51	C52	C53	C54	C56	C57	C58
1964/65	1.55	0.25	0.58	0.80	0.50	0.43	1.86
1974/75	1.40	0.46	0.58	0.96	0.50	0.59	1.71
1984/85	1.34	0.61	0.58	1.04	0.50	0.68	1.65
1994/95[1]	1.30	0.72	0.58	1.09	0.50	0.75	1.61

	C61	C62	C63	C64	C65	C67	C68
1964/65	3.11	0.50	1.15	1.60	2.00	0.86	3.72
1974/75	2.80	0.93	1.16	1.92	2.00	1.19	3.42
1984/85	2.68	1.22	1.16	2.08	2.00	1.37	3.30
1994/95[1]	2.60	1.45	1.16	2.19	2.00	1.50	3.22

	C71	C72	C73	C74	C75	C76	C78
1964/65	3.63	0.58	1.35	1.87	2.34	1.17	4.35
1974/75	2.36	0.78	0.98	1.62	1.69	0.84	2.88
1984/85	1.96	0.89	0.85	1.53	1.47	0.73	2.42
1994/95[1]	1.74	0.97	0.78	1.47	1.34	0.67	2.16

	C81	C82	C83	C84	C85	C86	C87
1964/65	0.83	0.13	0.31	0.43	0.54	0.27	0.23
1974/75	0.82	0.27	0.34	0.56	0.59	0.29	0.35
1984/85	0.81	0.37	0.35	0.63	0.61	0.30	0.41
1994/95[1]	0.81	0.45	0.36	0.68	0.62	0.31	0.46

[1] Forecast.

Key: 1 = HRW, 2 = SRW, 3 = WHI, 4 = EC, 5 = ASW, 6 = ARG, 7 = HRS, 8 = CWRS

TABLE C16. IMPORTED WHEAT CLASS MARKET SHARES IN AFRICA: ACTUAL AND CHANGES IN SIMULATED SHARES, 1985/86-1995/96

Year	European Community	Soft Red Winter	Hard Red Winter	Canadian Western Red Spring	Durum	Canadian Durum
	Percent					
1964/65[1]	49.6	13.1	26.3	10.9	0.0	0.0
1974/75[1]	40.0	9.2	17.0	6.2	13.5	16.1
1984/85[1]	46.6	19.9	14.5	5.0	9.6	4.4
1985/86-1995/96[2]	-0.8	+1.6	-3.1	-0.8	+0.1	+3.0

[1] Actual.

[2] Change in simulated market shares during this period.

TABLE C17. IMPORTED WHEAT CLASS MARKET SHARES IN ASIA: ACTUAL AND CHANGES IN SIMULATED SHARES, 1985/86-1995/96

Year	Australian Standard White	White	Soft Red Winter	Hard Red Winter	Hard Red Spring	Canadian Western Red Spring
	Percent					
1964/65[1]	24.0	12.1	0.0	46.7	0.9	16.3
1974/75[1]	21.8	16.3	11.6	27.0	2.5	20.7
1984/85[1]	28.5	19.1	18.3	7.2	7.5	19.3
1985/86-1995/96	-4.3	-3.4	+14.3	-4.0	-0.5	-2.3

[1] Actual.

[2] Change in simulated market shares during this period.

TABLE C18. IMPORTED WHEAT CLASS MARKET SHARES IN LATIN AMERICA: ACTUAL AND CHANGES IN SIMULATED SHARES, 1985/86-1995/96

Year	Hard Red Winter	European Community	White	Argentina	Soft Red Winter	Hard Red Spring	Canadian Western Red Spring	U.S. Durum
	Percent							
1964/65[1]	32.8	3.8	1.0	36.9	4.0	7.1	14.3	0.2
1974/75[1]	48.8	2.2	0.5	4.9	4.4	17.8	21.0	0.5
1984/85[1]	48.0	2.4	1.5	13.0	5.4	11.5	15.5	2.7
1985/86-1995/96[2]	+0.5	-0.2	-0.1	-2.4	-0.2	+0.6	+1.0	+0.8

[1] Actual.
[2] Change in simulated market shares during this period.

TABLE C19. IMPORTED WHEAT CLASS MARKET SHARES IN THE MIDDLE EAST: ACTUAL AND CHANGES IN SIMULATED SHARES, 1985/86-1995/96

Year	Australian Standard White	European Community	Soft Red Winter	White	Hard Red Winter	Canadian Western Red Spring
	Percent					
1964/65[1]	19.5	32.9	3.1	1.3	40.5	2.6
1974/75[1]	23.7	29.4	8.3	14.9	19.0	4.8
1984/85[1]	42.8	21.9	3.4	9.3	12.0	10.7
1985/86-1995/96[2]	+0.8	+0.6	-0.3	+0.8	-2.5	+0.6

[1] Actual.

[2] Change in simulated market shares during this period.

TABLE C20. IMPORTED WHEAT CLASS MARKET SHARES JAPAN: ACTUAL AND CHANGES IN SIMULATED SHARES, 1985/86-1994/95

Year	White	Australian Standard White	Hard Red Winter	Hard Red Spring	Canadian Western Red Spring
	---------------------------	-------------	Percent	-------------	---------------------------
1964/65[1]	20.9	12.4	26.7	0.0	40.0
1974/75[1]	19.2	18.5	24.7	15.2	22.4
1984/85[1]	17.1	18.4	22.9	18.1	23.4
1985/86-1995/96[2]	-0.7	-0.1	-2.0	+5.1	-2.5

[1] Actual.

[2] Change in simulated market shares during this period.

TABLE C21. MARKET SHARES OF WHEAT CONSUMPTION BY CLASS IN UNITED STATES: ACTUAL AND CHANGES IN SIMULATED SHARES, 1985/86-1995/96

Year	Hard Red Winter	Soft Red Winter	White	Hard Red Spring	Durum
	Percent				
1964/65[1]	42.7	21.7	9.6	21.1	4.8
1974/75[1]	45.8	20.0	6.6	21.6	6.0
1984/85[1]	48.7	25.0	7.5	15.1	3.8
1985/86-1995/96[2]	-0.3	-0.2	+0.1	-0.4	+0.2

[1] Actual.
[2] Change in simulated market shares during this period.

TABLE C22. IMPORTED WHEAT CLASS MARKET SHARES IN WORLD: ACTUAL AND CHANGES IN SIMULATED SHARES, 1985/86-1995/96

Year	Hard Red Winter	Soft Red Winter	White	European Community	Australian Standard White	Argentina	Hard Red Spring	Canadian Western Red Spring
				Percent				
1964/65[1]	26.1	4.0	6.3	13.1	14.0	9.6	1.2	25.7
1974/75[1]	24.2	7.0	9.7	13.2	14.9	4.0	6.4	20.7
1984/85[1]	19.1	7.1	6.0	18.2	15.9	8.4	5.1	20.2
1985/86-1995/96[2]	-1.3	+1.7	-0.1	+0.5	-0.4	-0.1	+0.6	-0.9

[1] Actual.
[2] Change in simulated market shares during this period.

Appendix D

Soviet Union Import Behavior

In recent years the Soviet Union has become a large and important wheat importing country, alone importing more than 10 million metric tons of wheat in each of the last six trade years. Since the USSR has become such an important player in the market, it only seemed right to analyze the wheat class importing behavior for this country along with the others analyzed in this study. Unfortunately, analysis was made virtually impossible by the erratic and inconsistent nature of Soviet wheat purchasing behavior.

Total wheat imports and market shares by class for the USSR are presented in Table E1. Throughout the time period total wheat imports have been volatile, ranging from 132 thousand metric tons (TMT) to 25,454 TMT. The distribution of purchases across classes also has been volatile and uneven. Of the five classes only CWRS was imported in each year. The EC was not a major exporter until the 1980s. The United States did not get involed in exporting wheat to the USSR until 1972 after diplomatic relations had resumed.

The wide, yearly fluctuations in total imports are not unexpected when the economic problems of the USSR and the vulnerability of large portions of its wheat producing area to adverse weather conditions are taken into account. These fluctuations, however, combined with the inconsistent behavior in importing individual wheat classes cause the data to be inconsistent and time series analysis difficult. Estimation of the 1972/73-1984/85 period was attempted but yielded poor results. This time period subsequently was divided into two periods to pre- and post-EC entrance into the Soviet market. Results were quite different between the two time periods, indicating that it would be inappropriate to model the entire period at one time. Splitting up the data into two time periods, however, resulted in a limited number of observations per period. With so few observations results, if they could be obtained at all, were questionnable. Further, because of Soviet market power and purchasing procedures (i.e., government-to-government negotiations), use of publicly quoted FOB prices is likely inappropriate, thereby explaining, in part, the poor results. The decision was made, then, not to include the USSR in the body of the study but instead in a short appendix.

TABLE D1. TOTAL WHEAT IMPORTS AND MARKET SHARES BY CLASS FOR THE USSR, 1963/64-1984/85

Year[1]	HRW	ARG	EC	ASW	CWRS	Total Imports
	Percent					TMT
1963	11.5	0.1	6.9	18.0	63.5	8,545
1964	0.0	3.1	5.7	49.8	41.5	1,762
1965	0.0	28.0	1.7	7.4	62.9	7,785
1966	0.0	0.6	4.9	0.0	94.6	2,739
1967	0.0	0.0	0.0	0.0	100.0	1,344
1968	0.0	0.0	0.0	0.0	100.0	132
1969	0.0	0.0	0.0	0.0	100.0	1,079
1970	0.0	0.0	0.0	0.0	100.0	263
1971	0.0	0.0	0.6	17.7	81.6	2,885
1972	61.2	0.0	5.1	6.6	27.1	13,785
1973	65.5	0.7	0.0	0.4	33.3	4,154
1974	38.1	26.4	0.0	25.5	10.1	2,575
1975	43.9	13.1	0.0	15.1	27.8	8,783
1976	68.2	3.6	0.0	9.5	18.7	3,868
1977	55.1	18.3	0.0	4.1	22.5	6,145
1978	59.3	0.0	0.1	3.2	37.5	4,317
1979	36.9	17.8	6.2	24.7	14.4	11,102
1980	22.1	22.8	5.5	18.9	30.7	13,029
1981	36.4	17.9	10.0	13.6	22.1	17,277
1982	18.7	24.0	19.3	5.7	32.2	17,593
1983	21.5	19.2	22.7	8.2	28.3	18,788
1984	24.7	15.9	23.9	8.0	27.4	25,454

[1] Trade year beginning July of year indicated.

Background Paper No. 2

Farm Programs and Grain Quality

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FARM PROGRAMS AND GRAIN QUALITY

William W. Wilson, Paul Gallagher, and Craig Anderson*

I. Introduction

Farm programs have played an important role in United States agriculture since at least 1933. There have been numerous programs with a gradual shift from price supports to income supports. These farm programs provide constraints and incentives which are transmitted throughout the production and marketing system and consequently may impact the quality of grain which is produced and marketed. There are two provisions of farm programs which are particularly important. One is the loan rate program and its associated premiums and discounts for quality differentials. The other is the target price program which results in higher prices associated with yield. To the extent there is an inverse relationship between yield and quality, then any program resulting in increased yields also has the potential to reduce quality. Impacts of the programs are influenced by a number of factors including underlying technological relationships, market incentives, and constraints which may exist in the production and marketing system.

The overall purpose of this report is to analyze the impacts of farm programs on grain quality. Specific objectives include: 1) a review of farm program legislation with particular attention to impacts on grain quality; 2) to analyze selected data to determine the extent of and dynamics in the trade-offs between yield and quality; and 3) to analyze the potential impacts of higher prices via the target price program on incentives to increase yields and decrease quality. The concepts developed and presented in this report are general with an application to wheat. However, the principals could be applied to any grain in which commercial premiums and discounts exist for particular quality characteristics, and in which measureable trade-offs exist in production between yield and quality. These conditions exist in the case of wheat and are especially important in the case of hard wheats. Consequently, the empirical analysis is limited to two classes of wheat. These include Hard Red Spring, which is predominately grown in North Dakota and Hard Red Winter, in which Kansas is the largest producing state. In both cases, premiums and discounts play an important role in the marketing system and yield is inversely related to an important quality characteristic, protein in this case.

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In the first section below, important features of the farm programs are described as well as their potential impacts on quality. Detail is provided on the loan rate premiums and discounts, and comparisons are made to market premiums and discounts. Section III provides a detailed review and description of data used in subsequent analysis. The historical behavior of protein premiums are analyzed. In addition, the trade-off which exists between yield and protein is described. A simple budget analysis of the impacts of loan programs is provided in Section IV. A detailed analysis of farm programs on yield-protein choices is presented in Section V. This analysis incorporates yield response to wheat and fertilizer prices, plus technical trade-offs between yield and protein. Profit-maximizing choices between alternative yield and protein levels are simulated to analyze the impacts of alternative prices.

II. Government Program Effects on Grain Quality

One of the main purposes of government farm policies since World War II has been to support farm incomes. Several different policies and program mechanics have been used over time to achieve this goal. The two major farm program provisions used to support farm incomes have been the loan rate and deficiency payment/target price. Loan rate provisions have been in effect in wheat programs since prior to World War II. The deficiency payment system has been used since 1973; however, it did not have major effects until 1977 because market prices generally exceeded the loan rate and in some cases the target price. The purpose of this section is to describe features of government price and income support policies which may have an impact on wheat quality. Two features of farm policy of importance include the premiums and discounts associated with the loan rate program, and the proven yield provision associated with the deficiency payment. Each is discussed in the following sections, however, first a brief history of farm program provisions is presented.

Wheat program participation prior to 1964 was mandatory in most years. Acreage allotments were imposed along with marketing quotas in the years 1951 and 1954 through 1963 (Cochrane and Ryan 1976). Acreage allotments were set at the amount of acreage needed to produce a crop which, together with carryover and imports, would provide a supply equal to a normal year's domestic consumption and exports plus an allowance for reserve. Marketing quotas were used along with acreage allotments as a more stringent means of controlling output. When expected supply for a year exceeded estimated use by a specified amount, marketinq quotas had to be proclaimed by the Secretary of Agriculture. A quota became effective by a two-thirds vote of approval by wheat producers. When marketing quotas were approved, compliance with acreage allotment was mandatory. When marketing quotas were disapproved, the level of price supports was lowered substantially.

Beginning in 1964, farm programs no longer required mandatory participation and marketing quotas were voted out. During the period 1964 to 1973, loan rates were reduced and farm income was supported by domestic certificate payments and export certificate payments. These were cash payments based on a percentage of production on a producers allotted acres.

In 1973 marketing certificates were replaced by target price/deficiency payments as a means of supporting farm income. Years 1974 to 1976 marked a period when wheat prices increased dramatically and were higher than loan rates. Hence, government participation in the form of income support, directly or via prices, to wheat producers was virtually nonexistent. Implementation of the target price program did not effectively begin until 1977 and is still in effect today. The per bushel income support payment called a deficiency payment is the difference between the target price and the average price received by farmers in the first five months of the marketing year, or the loan rate, whichever is higher. Historical loan rates, target prices, and deficiency payments are presented in Table 1. Deficiency payments increased dramatically in 1984 and have since nearly doubled. As a result, in recent years payments which are by definition based on yield as described below, comprise an increasing proportion of producer's income.

A producer's total payment is calculated by multiplying the per bushel deficiency payment times the program acres, times the proven yield. Program acres are a historical average of acres planted to wheat and proven yield is a historical average of yield on program acres. These historical averages

TABLE 1. HISTORICAL LOAN RATE, TARGET PRICE, AND DEFICIENCY PAYMENT FOR WHEAT IN THE UNITED STATES

Year	National Average Market Price	Loan Rate	Target Price	Actual Deficiency Payment	Deficiency Payment as Percent of Target Price
	dollars/bu				%
1974	4.09	1.37	2.05	--	--
1975	3.56	1.37	2.05	--	--
1976	2.73	2.25	2.29	--	--
1977	2.33	2.25	2.90	.65	22.4
1978	2.97	2.35	3.40	.52	15.3
1979	3.78	2.50	3.40	--	--
1980	3.91	3.00/3.30	3.08/3.63	--	--
1981	3.65	3.20/3.50	3.81	.15	3.9
1982	3.55	3.55/4.00	4.05	.50	12.3
1983	3.53	3.65	4.30	.65	15.1
1984	3.38	3.30	4.38	1.00	22.8
1985	3.08	3.30	4.38	1.08	24.6
1986	2.40	2.40	4.38	1.98	45.2

SOURCE: USDA, Statistical Reporting Service, "Agricultural Statistics," various issues.

changed over time meaning producers were able to increase or decrease the program acres devoted to wheat and increase proven yield by altering variety choices or production practices. The Food and Security Act of 1985 is the most recent major farm legislation. In that legislation, several changes were made in the loan rate and target price provisions. The loan rate for wheat in 1986 was reduced 20 percent, from $3.30/bu to $2.40, while the target price remained at $4.38/bu for 1986. This meant that due to low market prices which were near the loan rate in 1986 the deficiency payment increased from $1.08/bu to $1.98/bu in 1986.

Loan Program Premiums and Discounts

The loan rate program was the primary mechanism for price support prior to 1973. An important component of the loan rate program was the provision that allowed for adjustment in the loan price a farmer receives based on quality differentials. Each year a schedule of premiums and discounts is published in the provisions for the loan rate program.[1] In addition to the schedule of premiums and discounts for wheat established through the loan program, the market establishes premiums and discounts reflecting the market determined value of quality attributes. These premiums and discounts provide incentives which have the potential to influence yields and to influence the allocation of wheat between the market and the government via loan forfeitures. This allocation may take place within as well as between crop years. Administration of the loan rate program has included premiums for protein above a certain level and discounts for grade differentials. In addition, discounts originally used for loan rate adjustments have changed over time. In particular, the sedimentation tests used to determine the quality of protein content was used with associated premiums and discounts. Also, discounts were assessed via the loan rate program for particular varieties. Each of these features are discussed below.

Protein premiums as provided by the loan rate program have been relatively stable through time (Table 2). The premium applicable to HRW[2] 13 percent protein over HRW 10.5% protein has been 4.5 cents/bu since

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[1] These price adjustments are applied immediately in the case of warehouse loans. In the case of farmer-owned loans they were applied in the final settlement if the grain was forfeited.

[2] HRW and HRS refer to Hard Red Winter and Hard Red Spring wheat, respectively.

Table 2. HISTORICAL LOAN RATE VERSUS MARKET PREMIUMS FOR HRS AND HRW

Market Year	HRW Loan Rate Premium 13% Over 10.5%[a]	HRW Market Premium 13% Over Ordinary[c]	Difference	HRS Loan Rate Premium 15% Over 11.5%[a]	HRS Market Premium 15% Over 12%[b]	Difference
	----------	----------	---------- cents/bu	----------	----------	----------
1965	4.50	-2	-6.50	10.50	11	.50
1966	4.50	5	.50	10.50	1	-9.50
1967	4.50	3	-1.50	10.50	4	-6.50
1968	4.50	17	12.50	10.50	22	11.50
1969	4.50	3	-1.50	10.50	17	6.50
1970	4.50	15	10.50	10.50	12	1.50
1971	4.50	6	1.50	10.50	16	5.50
1972	4.50	5	.50	10.50	8	-2.50
1973	4.25	8	3.75	10.50	12	-1.50
1974	4.25	44	39.75	10.50	44	43.50
1975	4.50	42	37.50	10.50	71	60.50
1976	4.50	31	26.50	10.50	36	25.50
1977	4.50	9	4.50	16.00	19	3.00
1978	4.50	3	-1.50	16.00	11	-5.00
1979	4.50	9	4.50	16.00	16	0.00
1980	4.50	5	.50	16.00	50	34.00
1981	4.50	3	-1.50	16.00	14	-2.00
1982	4.50	19	14.50	16.00	18	2.00
1983	4.50	21	16.50	16.00	20	4.00
1984	4.50	19	14.50	16.00	53	37.00
1985	4.50	21	16.50	16.00	74	58.00
1986	4.50	23	18.50	16.00	78	62.00

[a] ASCS, *Schedule of Premiums and Discounts*, various issues;
[b] Minneapolis Grain Exchange, *Statistical Annual*, various issues;
[c] USDA/ERS, *Wheat Outlook and Situation*, various issues.

1965 with the exception of 1973 and 1974 in which it decreased to 4.25 cents/bu. From 1950 to 1965 the premium rose from 3 cents to 4 cents/bu for HRW 13 percent protein. Throughout the 1950s and early 1960s the protein premium for HRS 15 percent protein was 6 cents/bu. The premium for HRS 15 percent protein was 10.5 cents/bu from 1965 to 1976 increased to 16 cents/bu in 1977. Figure 1 shows historical behavior of HRS market versus loan program premiums for 15 percent protein and the same for HRW 13 percent premium.

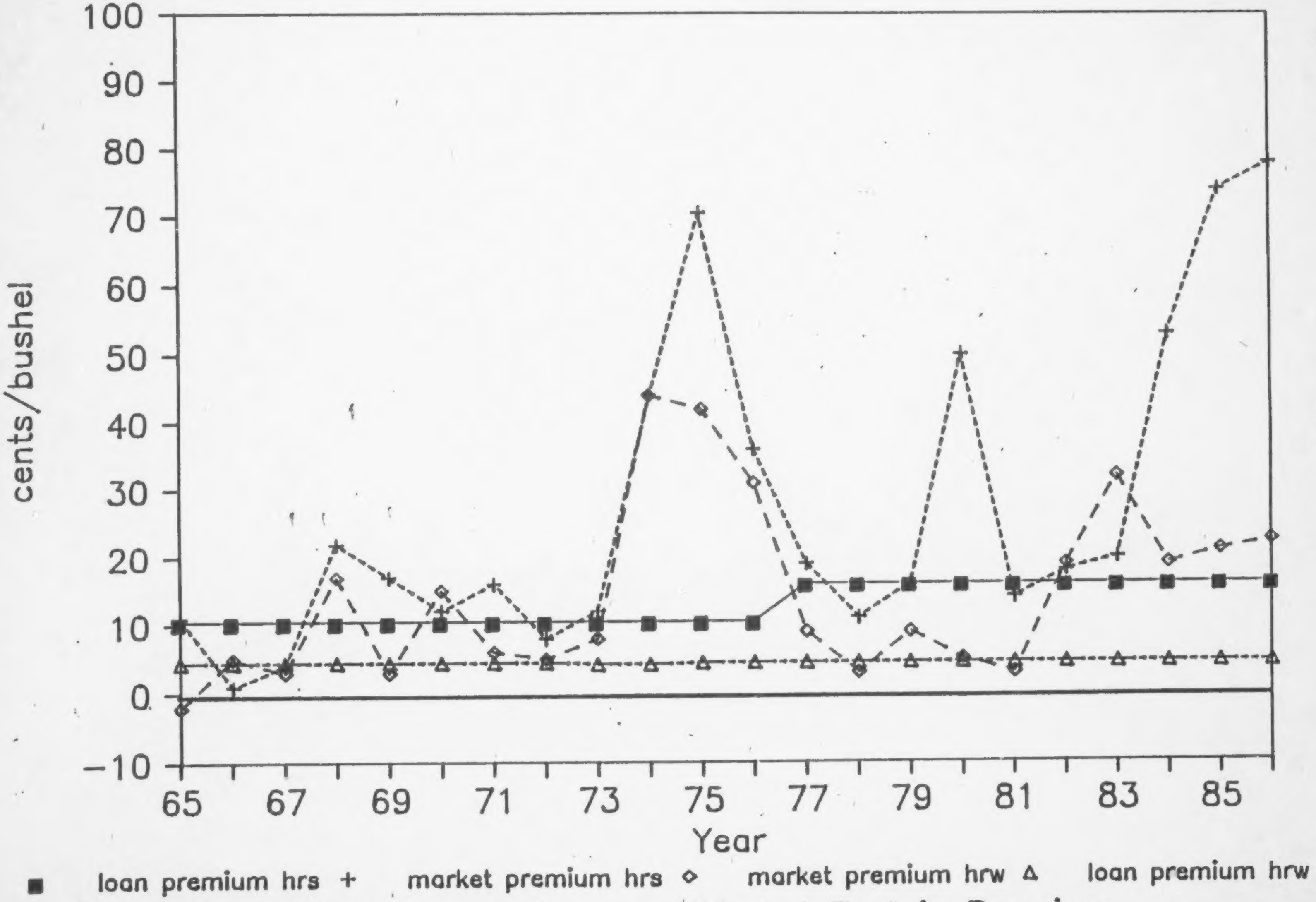

Figure 1. Historical Loan Rate and Market Protein Premium for HRS 15% and HRW 13%

The loan rate premium has been less than the market premium in most of the past 22 years. The market premium was less than the loan rate premium in only five years for both HRS and HRW. More recently, the spread between the loan rate premium has been increasing steadily since 1982. In general, the loan rate premiums for protein have not reflected market fundamentals and this spread has been increasing in recent years in both the HRW and HRS market. This situation has a potential to distort production decisions related to variety choice and fertilizer application to the extent that a trade-off exists between yield and protein. Storage decisions are also likely distorted by the disparity in government and market protein premiums. Producers have the incentive to put low protein wheat under loan and forfeit that loan if market prices for that type of wheat do not appreciate. The market premium is typically high enough to encourage commercial sales of higher protein wheat. Consequently, the program spreads relative to the market result in isolating lower protein wheat from the market and may have discouraged development of commercial markets for lower protein wheats.

Other features of the loan rate program have changed over time. Prior to 1973, two other measures were used in the loan rate program to reflect end-use quality in program prices. The first was called a sedimentation test which measures the quality of protein content in wheat (Zeleny). This test is performed by suspending ground wheat in water and treating it with lactic acid. The resulting portion of the wheat that within five minutes settles to the bottom of a graduated cylinder is the sedimentation value. Values range from 3 for very weak wheat to 70 for very strong wheat. Premiums and discounts for different sedimentation values were used during 1963 and 1964 (Table 3).

TABLE 3. SEDIMENTATION VALUE PREMIUMS AND DISCOUNTS PROVIDED BY THE LOAN RATE PROGRAM, 1963 TO 1964

Sedimentation Value 1963	Premium or Discount 1963	Sedimentation Value 1964	Premium or Discount 1964
	cents/bu		cents/bu
21 and below	-9	22 and below	-6
22-23	-8	23-25	-5
24-25	-7	26-28	-4
26-27	-6	29-31	-3
28-29	-5	32-34	-2
30-31	-4	35-37	-1
32-33	-3	38-42	0
34-35	-2	43-45	+1
36-37	-1	46-48	+2
38-42	0	49-51	+3
43-44	+1	52-54	+4
45-46	+2	55-57	+5
47-48	+3	58-60	+6
49-50	+4	61-63	+7
51-52	+5	64-66	+8
53-54	+6	67 and above	+9
55-56	+7		
57-58	+8		
59-60	+9		
61-62	+10		
63-64	+11		
65 and over	+12		

SOURCE: ASCS, Schedule of Premiums and Discounts, various issues.

Another factor used prior to 1973 to reflect quality differentiation in the loan rate program was the discounts associated with varieties. This discount was used throughout the 1960s and up through 1972. Discounts were applied on varieties in each class of wheat which were deemed "undesirable" due to poor quality characteristics.[3] The varieties and number of varieties changed over time to reflect newly released wheats. Generally, a half dozen varieties were subject to discount in any given year. Examples of "undesirable" HRW varieties in the early 1970s included Blue Jacket, Purkof, Cache, Red Chief, Staffor, and Yogo. Examples of "undesirable" HRS varieties included Red River 68, Era, and Neepawa. The discount was 20 cents/bu throughout the time period. This discount ended in 1973 and is no longer used. By abandoning these measures of end-use performance (i.e., sedimentation and variety) the loan rate program became less capable of reflecting end-use performance to program participants.

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[3] The term "undesirable" was used in the schedule of premiums and discounts.

Wheat is subject to other premiums and discounts under the loan program. Discounts and premiums are applied by grade and not on an individual factor basis as long as the grade is "sample grade" or better (Table 4). Additional discounts based on factors did apply on test weight and damage if the wheat is No. 4, or No. 5, or sample grade in specific years as shown in Table 4 and Table 5. There was a substantial reduction in the discount applied to damaged kernels beginning in 1980 (Table 5). Market premiums and discounts for grade factors are measured differently than those in the loan rate provisions. In market transactions, discounts are normally taken for individual factors such as test weight, damaged kernels, or foreign material. Table 6 shows an example of current market premiums and discounts at Minneapolis for HRS wheat.

It is difficult to make comparisons of market discounts to loan rate discounts because they are not quoted on the same basis. In general, the loan rate discounts by grade while the market discounts on the individual factors that determine grade. Individual wheat factors which determine grade are presented in Table 7. Comparisons must be tentative using the quoted market discounts and premiums because they are for a particular point in time and,

TABLE 4. LOAN RATE PREMIUMS AND DISCOUNTS ON WHEAT FOR GRADE

Year	Grade					
	No. 1	No. 2	No. 3	No. 4[b]	No. 5[c]	No. 4/No. 5[d]
	¢/bu					
1954-1961	+1[a]	-1	-3	-6	-9	-6
1962	+1[a]	-1	-3	f	f	-6
1963	+1[a]	-1	-3	-6	-9	-6
1964	+1[a]	-1	-2	g	g	-6
1965-1976	+2[e]	-1	-3	-6	-9	N/A
1977-1986	0	-2	-4	-6	-9	N/A

[a] $0.01 premium for No. 1 heavy.
[b] On test weight otherwise No. 3.
[c] On test weight otherwise No. 3.
[d] No. 4 or No. 5 because containing durum and or red durum.
[e] No. 3 or better heavy
[f] Test weight discount for No. 4 or No. 5 or sample.
[g] Test weight discount for No. 4 or No. 5 or sample.

Test Weight	f 1962	g 1964
	cents/bu	
53-54.9	-6	-4
50-52.9	-9	-6
49	-13	-9
48	-17	-12
47	-21	-15
46	-25	-18
45	-29	-21
44	-35	-25
43	-41	-29
42	-47	-33
41	-53	-37
40	-59	-41

TABLE 5. ADDITIONAL LOAN RATE DISCOUNTS FOR DAMAGED KERNELS

Total Percent Damage	1951 No 4 or No. 5	1962 No. 4, No. 5 Or Sample Grade	1977 & 1978 Sample Grade	1980-1986 Sample Grade
		cents/bu		
7.1- 8.0	-1	-1	N/A	N/A
8.1- 9.0	-2	-2	N/A	N/A
9.1-10.0	-3	-3	N/A	N/A
10.1-11.0	-4	-4	N/A	N/A
11.1-12.0	-5	-5	N/A	N/A
12.1-13.0	-6	-6	N/A	N/A
13.1-14.0	-7	-7	N/A	N/A
14.1-15.0	-8	-8	N/A	N/A
15.1-16.0	N/A	-10	-10	-2
16.1-17.0	N/A	-12	-12	-4
17.1-18.0	N/A	-14	-14	-6
18.1-19.0	N/A	-16	-16	-8
19.1-20.0	N/A	-18	-18	-10
20.1-21.0	N/A	-20	-20	-12
21.1-22.0	N/A	-22	-22	-14
22.1-23.0	N/A	-24	-24	-16
23.1-24.0	N/A	-26	-26	-18
24.1-25.0	N/A	-28	-28	-20
25.1-26.0	N/A	-30	-30	-22
26.1-27.0	N/A	-32	-32	-24
27.1-28.0	N/A	-34	-34	-26
28.1-29.0	N/A	-36	-36	-28
29.1-30.0	N/A	-38	-38	-30
over 30.1	N/A	-60	3 cents each percent over 50.0	3 cents each percent over 30.0

even though they may be representative of the market as a whole, they do change through time. Damage has been one of the more limiting factors in recent years in grade determination in HRS and is used here to make a comparison. The market discount for a sample with 4 percent damage would be 10 cents assuming no other factor discounts. For comparison, 4 percent damaged kernels would be graded No. 2 and would result in a 2 cent/bu discount from the loan rate (Table 4). Differences also exist between the other market

TABLE 6. MARKET DISCOUNTS FOR HRS, FEBRUARY 1987

Item	Discounts
Test weight	2¢ ea 1/2# 58-56#, 3¢ ea 1/2# 56-54#, 5¢ ea 1/2# 54-56.
Moisture	1¢ ea 1/4# 13.5-14.0% MAX
Foreign material	1¢ 1/2% .5-5% MAX
Damage	2¢ ea 1% 0-3% (.9 ALLWD) 4¢ ea 1% 3-5% 6¢ ea 1% 5-7%
Sprout damage	2¢ ea .5% ove .5% 5%MAX
Shrunk and broken	1¢ ea 1% 3-5% 2¢ ea 1% 5-15%
Total defects	1¢ ov 3-5%
Wheat of other classes	2¢ ea 1% ov 3-10% MAX
Contrasting classes	1¢ ea 1% 1-10% MAX

SOURCE: Continental Grain Company.

discounts and those implied in the loan rate. A principal difference is that for wheat with less than 15 percent damage (in 1986), the loan rate discounts by grade, whereas the market discounts are cumulative. If other factor discounts were included besides damage (e.g., test weight, foreign matter) the comparison would be more dramatic.

An alternative comparison is made possible because of annual surveys of country elevators in North Dakota on discounting practices. Results of that survey are shown in Table 8 and suggest that in general, market premiums and discounts have increased in the past three years. For example, the

TABLE 7. WHEAT QUALITY FACTORS DETERMINING GRADE

	Minimum Limits of-		Maximum Limits of-						
	Test Weight Per Bu.		Damaged Kernels					Wheat of Other Classes[4]	
Grade	Hard Red Spring Wheat or White Club Wheat[1]	All Other Classes and Sub-Classes	Heat Damaged Kernels	Total[2]	Foreign Material	Shrunken & Broken Kernels	Defects[3]	Contrasting Classes	Total[5]
	lbs		percent						
U.S. No. 1	58.0	60.0	0.2	2.0	0.5	3.0	3.0	1.0	3.0
U.S. No. 2	57.0	58.0	0.2	4.0	1.0	5.0	5.0	2.0	5.0
U.S. No. 3	55.0	56.0	0.5	7.0	2.0	8.0	8.0	3.0	10.0
U.S. No. 4	53.0	54.0	1.0	10.0	3.0	12.0	12.0	10.0	10.0
U.S. No. 5	50.0	51.0	3.0	15.0	5.0	20.0	20.0	10.0	10.0

U.S. sample grade--

U.S. sample grade is wheat that:

(a) Does not meet the requirements for grades U.S. Nos. 1, 2, 3, 4, or 5; or

(b) Contains 8 or more stones or any number of stones which have an aggregate weight in excess of 0.2 percent of the sample weight, 2 or more pieces of glass, 3 or more crotalaria seed (Crolataria spp.), 2 or more castor beans (Ricinus communis), 4 or more particles of an unknown foreign substance(s) or a commonly recognized harmful or toxic substance(s), or 2 or more rodent pellets, bird droppings, or an equivalent quantity of other animal filth per 1,000 g of wheat; or

(c) Has a musty, sour, or commercially objectionable foreign odor (except smut or garlic odor); or

(d) Is heating or otherwise of distinctly low quality.

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[1] These requirements also apply when Hard Red Spring wheat or White Club wheat predominate in a sample of Mixed wheat.

[2] Includes heat-damaged kernels.

[3] Defects include damaged kernels (total), foreign material, and shrunken and broken kernels. The sum of these three factors may not exceed the limit for defects for each numberical grade.

[4] Unclassed wheat of any grade may contain not more than 10 percent of wheat of other classes.

[5] Includes contrasting classes.

SOURCE: Federal Register, Vol. 52, No. 125 (June 30, 1987).

TABLE 8. AVERAGE PRICE ADJUSTMENTS FOR EACH FACTOR AMONG NORTH DAKOTA COUNTRY ELEVATORS (FALL OF 1984, 1985, AND 1986)

Commodity (Base Grade)	Factor	1984 Average	1985 Average	1986 Average
		¢/bu.		
HRS	57 lbs. test weight	-1.9	-1.8	-2.9
#1 DNS	14.5% moisture	-5.9	-6.8	-6.5
14% Protein	16% protein	41.0	63.4	62.6
	12% protein	-38.0	-67.4	-43.9
	4% damaged kernels	-2.0	-6.6	-8.9
	1% foreign material	-1.4	-1.3	-1.7
	5% shrunken and broken kernels	-2.2	-3.0	-4.2
	2% contrasting classes	-1.6	-3.2	-3.5
	5% wheat of other classes	--	-7.0	-8.6

SOURCE: Clow, B., W. Wilson, and R. Hielman, Pricing and Marketing Practices for North Dakota Durum and HRS Wheat 1986 Crop Year. Department of Agricultural Economics, North Dakota State University, Fargo.

discount for 4 percent damaged kernels (i.e., No. 2) rose from an average of 2 cents in 1984 to 8.9 cents in 1986. The individual factors for discount in Table 4 are the factor levels allowable in order for wheat to grade No. 2. In adding up the discounts for each factor except protein, the total possible discount for wheat (i.e., on all factors to the limit) that grades No. 2 by the market according to the survey was 36 cents/bu in 1986. The discount for wheat grading No. 2 by the loan rate program is 2 cents/bu. Wheat must meet the limit of only one of the factors listed in Table 7 in order to grade No. 2 (except moisture and protein). In reality wheat would not likely be discounted by all factors and only one or two factors would be limiting for discount purposes. Generally, damaged kernels have been one of the more limiting factors in grade determination in this time period.[4]

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[4] The Grain Quality Improvement Act of 1986 directed ASCS to collect information on adjusting their premiums and discounts to reflect market prices.

There is an important impact of the differential (and apparently growing differential) between loan rate and market premiums and discounts. Most important is the allocation of wheat with different qualities between the loan program and market. In general, this differential results in higher quality wheat being sold commercially,[5] while the poorer quality wheat being subject to greater market discounts, would be put under loan and stored since the applicable discounts would be substantially less. With market prices hovering around loan levels this wheat has the potential to be stored for an extended time period and only gradually being released to the market. For comparison, if loan rate premiums/discounts reflected or exceeded those of the market, the incidence of relatively poor quality wheat would likely not be reduced due to much of it being weather related. Rather, it would result in the poor quality wheat being sold on to the market directly, rather than being put under loan and stored. In this case the loan rate would support prices of the higher quality grain, rather than the lower quality grain as currently is the case.

Deficiency Payment Program Provisions

Deficiency payment programs have the potential along with the loan rate programs to have a long term impact on wheat quality. This program was introduced in 1973 and is still in existence today. Historic deficiency payments and target prices were presented in Table 1.

One of the provisions used to determine producer payments is the proven yield concept. Traditionally, proven yield was a five-year moving average of an individual producer's past yields. In other words, the formula for proven yield changed through time resulting in a producer's proven yield being adjusted each year. This encouraged producers to maximize proven yields in order to achieve the highest deficiency payment possible. During the 1980s market prices and loan rates have fallen, increasing deficiency payments to near $2.00/bu in 1986. This increases the incentive to maximize yield potentially at the expense of quality, compared to when deficiency payments were low or nonexistent.

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[5] Domestic millers have methods of determining where the higher quality wheats are located and have the potential to purchase by location. Millers can also specify other factors such as falling numbers, pesticide residue and in some cases can specify or evaluate for end-use factors such as sedimentation before shipment.

The most recent legislation, the Food and Security Act of 1985, resulted in a change in determination of proven yield. Proven yield for 1986 was now determined as the average yield from 1981 to 1985, excluding the high and low years. This was frozen for 1987 to 1990 and may be reduced 10 percent by the year 1990. Farm base acres for wheat were also frozen at 1985 levels in 1986 (Glaser 1985).

III. Data Description and Analysis of Data

The purpose of this section is to describe the data used in the analysis presented in subsequent sections. Data are presented for both North Dakota and Kansas. Sources of data for the study include: _Minneapolis Grain Exchange Statistical Annual_, (Minneapolis Grain Exchange), _Wheat Situation and Outlook_ (USDA), _North Dakota Wheat Varieties_ (North Dakota Crop and Livestock Reporting Service), _North Dakota Wheat Quality Report_, (North Dakota Wheat Commission) _Kansas Wheat Quality_ (Kansas Crop and Livestock Reporting Service), and experiment station trials data for both North Dakota and Kansas. The behavior of premiums is discussed first, followed by agronomic data.

Protein premiums paid by the market vary radically from year-to-year compared with the protein premiums offered by the loan rate program as shown in the previous section (Figure 1).. The two major markets which provide information on protein premiums are Kansas City for HRW and Minneapolis for HRS. Historical protein premiums for each are shown in Figure 2. The protein premium for HRW is the price difference between ordinary and 13 percent protein, that for HRS is the price difference between 15 and 12 percent protein HRS.[6] Protein premiums for HRW and HRS have historically moved in the same direction while protein premiums for HRS have been higher.

The average protein premiums in Figure 2 over the time period were 35 cents/bu and 14 cents/bu, respectively, for HRW and HRS. However, there has been a sporadically increasing trend over the time period. Abnormally high premiums occurred during 1975, followed by a general decline which approached zero. Since the early 1980s the premium for protein in each market has increased dramatically reaching successively higher levels. The reason for the dramatic increase in protein premiums in recent years is due to the simultaneous reduction in protein levels in both the Kansas and North Dakota crops. Appendix A provides a statistical analysis of factors influencing protein premiums.

State average yields and protein levels for North Dakota and Kansas are presented in Figures 3 and 4. Yield for both states has trended upwards over the past 20 years. Kansas hard red winter, by its nature, is a higher yielding wheat than the hard red spring wheat grown in North Dakota averaging four to five bushels more per acre. Kansas hard red winter has lower protein levels than hard red spring wheat grown in North Dakota. North Dakota protein levels are about 2 percentage points higher than that for Kansas HRW. Protein levels

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[6] Comparisons could also be made at other protein levels and the general behavior would be similar, though the levels would differ.

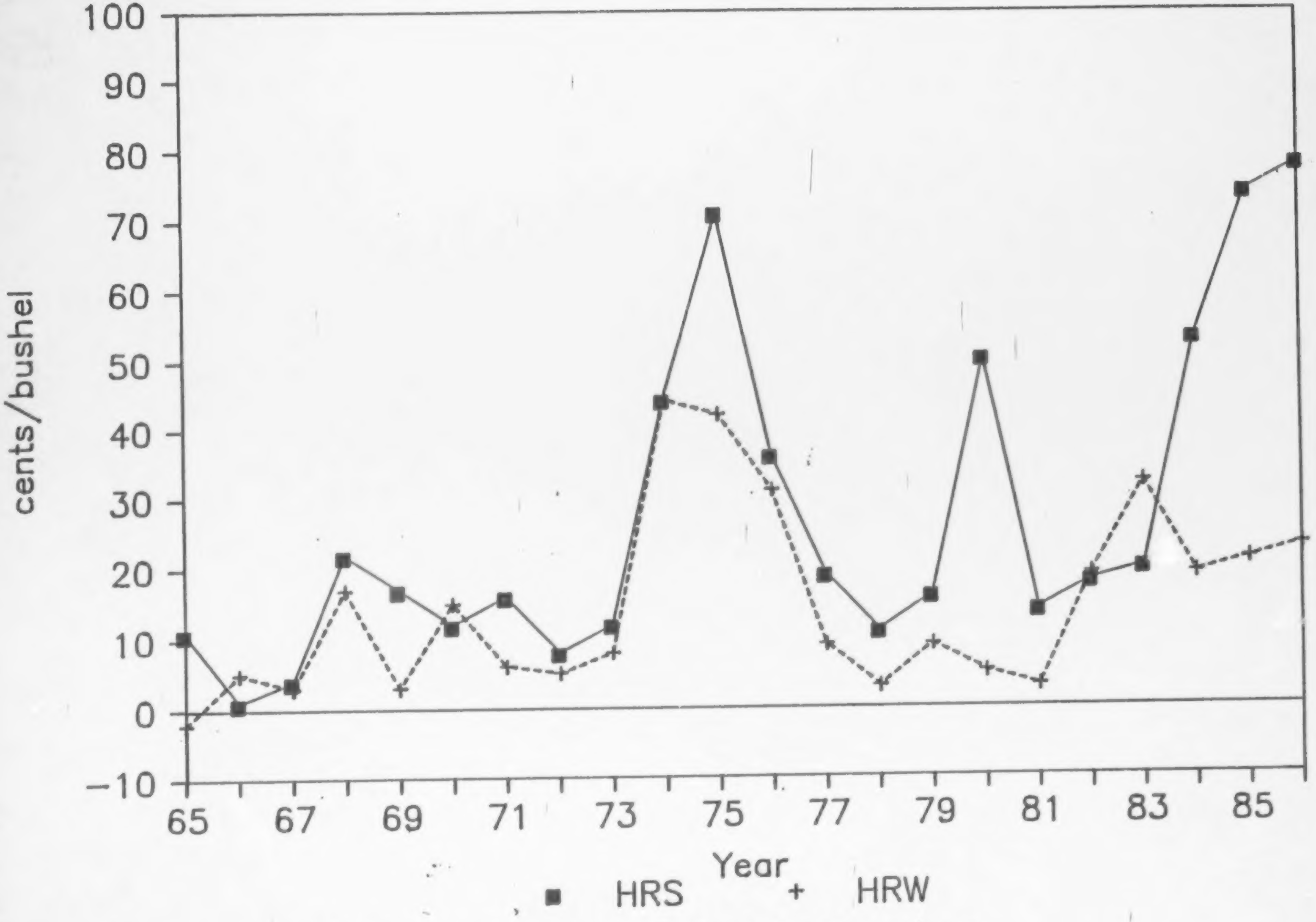

Figure 2. HRS and HRW Market Protein Premium
15%−12% HRS and 13%−ord. HRW

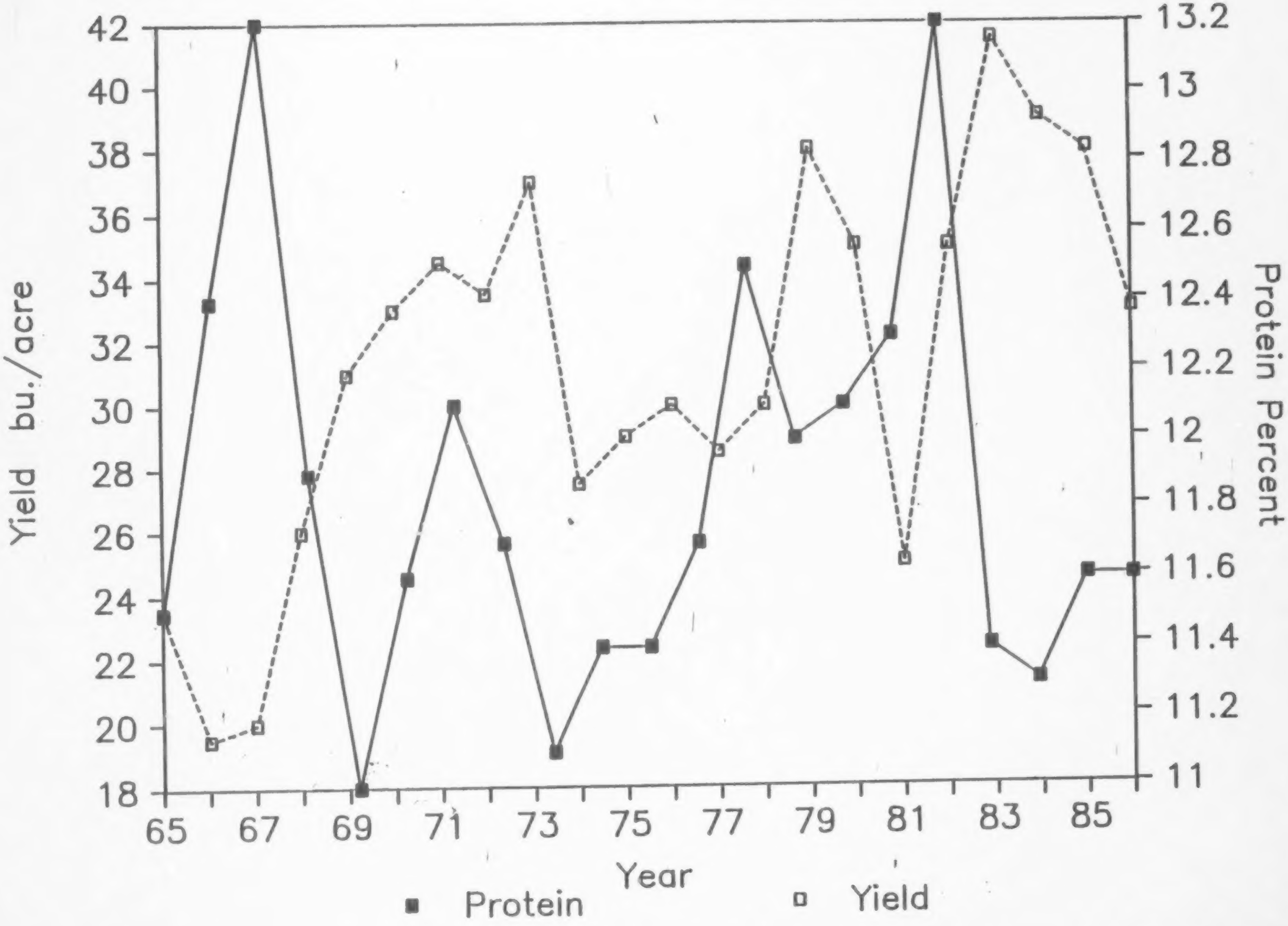

Figure 3. Kansas State Average Yield and Protein Level, 1965–1986

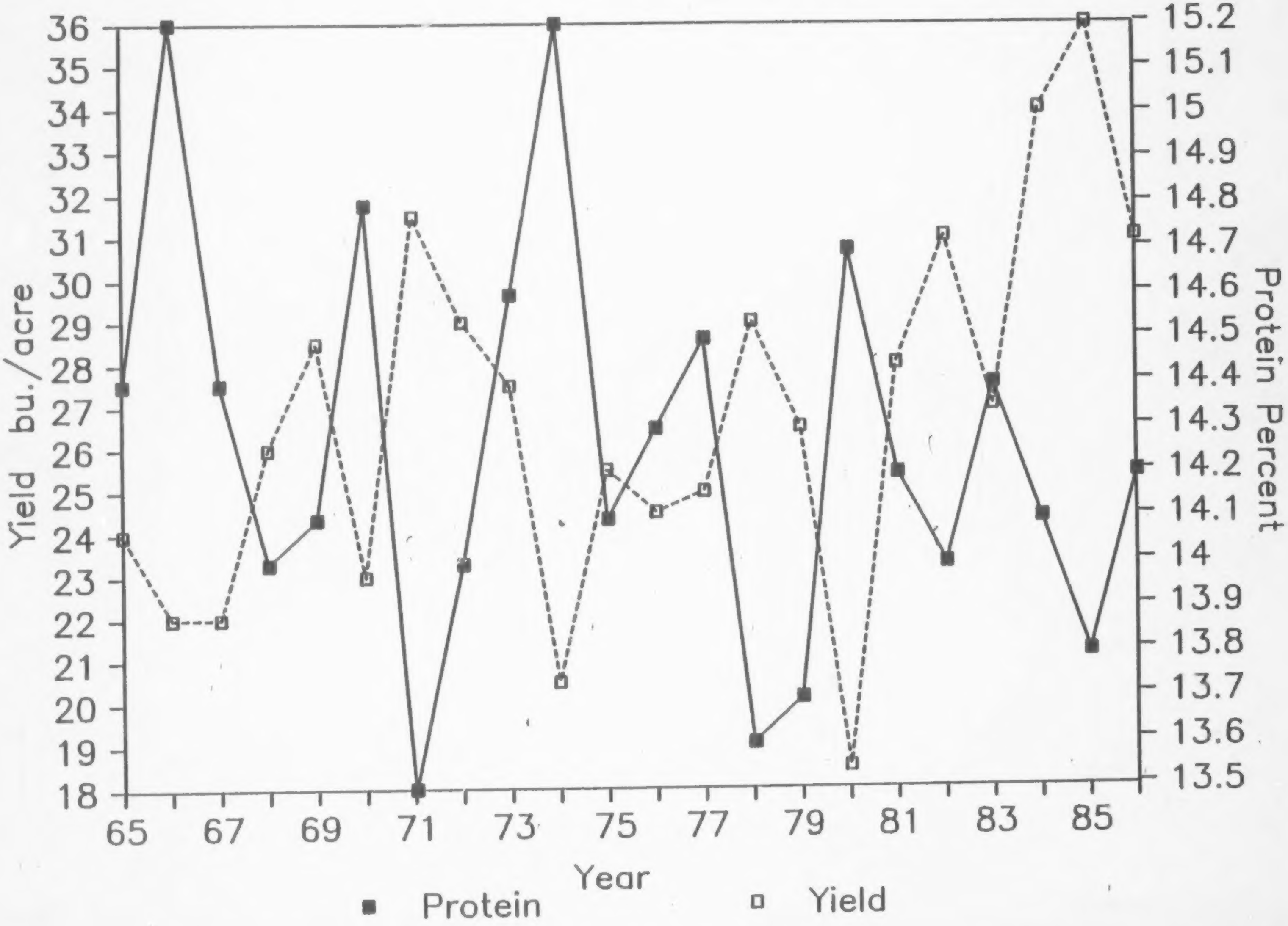

Figure 4. North Dakota State Average Yield and Protein Level, 1965–1986

in both North Dakota and Kansas have been relatively constant through the late 1970s, and thereafter, trended slightly downward. Kansas average protein level from 1965 through 1986 averaged 11.6 percent while North Dakota average was near 14.2 percent.

Since the 1940s, there has been increased interest in the development of short wheat varieties in the United States (Dalrymple). Prior to 1940, most United States wheat breeders focused attention on tall wheats for high yield potential. A new stage of development was provided by the introduction of semi-dwarf germplasm in 1946 and by the introduction of the first American semi-dwarf variety, Gaines in 1962, which was a soft white wheat.

The first semi-dwarf spring wheat variety released in North Dakota was Red River 68 in 1968, while Sturdy was the first HRW variety released in 1966. Technical changes in wheat breeding in the form of semi-dwarf wheat varieties in Kansas and North Dakota have been increasingly made available to and adopted by producers. Semi-dwarf varieties, in general, exhibit higher yield and lower protein levels compared to medium or tall straw varieties. Figure 5 presents the adoption of semi-dwarf varieties by North Dakota and Kansas wheat producers. The adoption rate of semi-dwarf varieties in North Dakota began in 1969, steadily increasing through 1985. The percent of acreage planted to semi-dwarf varieties declined in 1986 primarily due to the adoption of the variety Stoa, which is a medium straw wheat that along with high protein levels has high yield potential. Technical change in wheat breeding in Kansas has taken two steps in the past 20 years. Three basic variety groups have existed: tall wheats, medium-tall, and semi-dwarfs. The varieties released between 1965 and 1975 represent the medium-tall wheats and those released

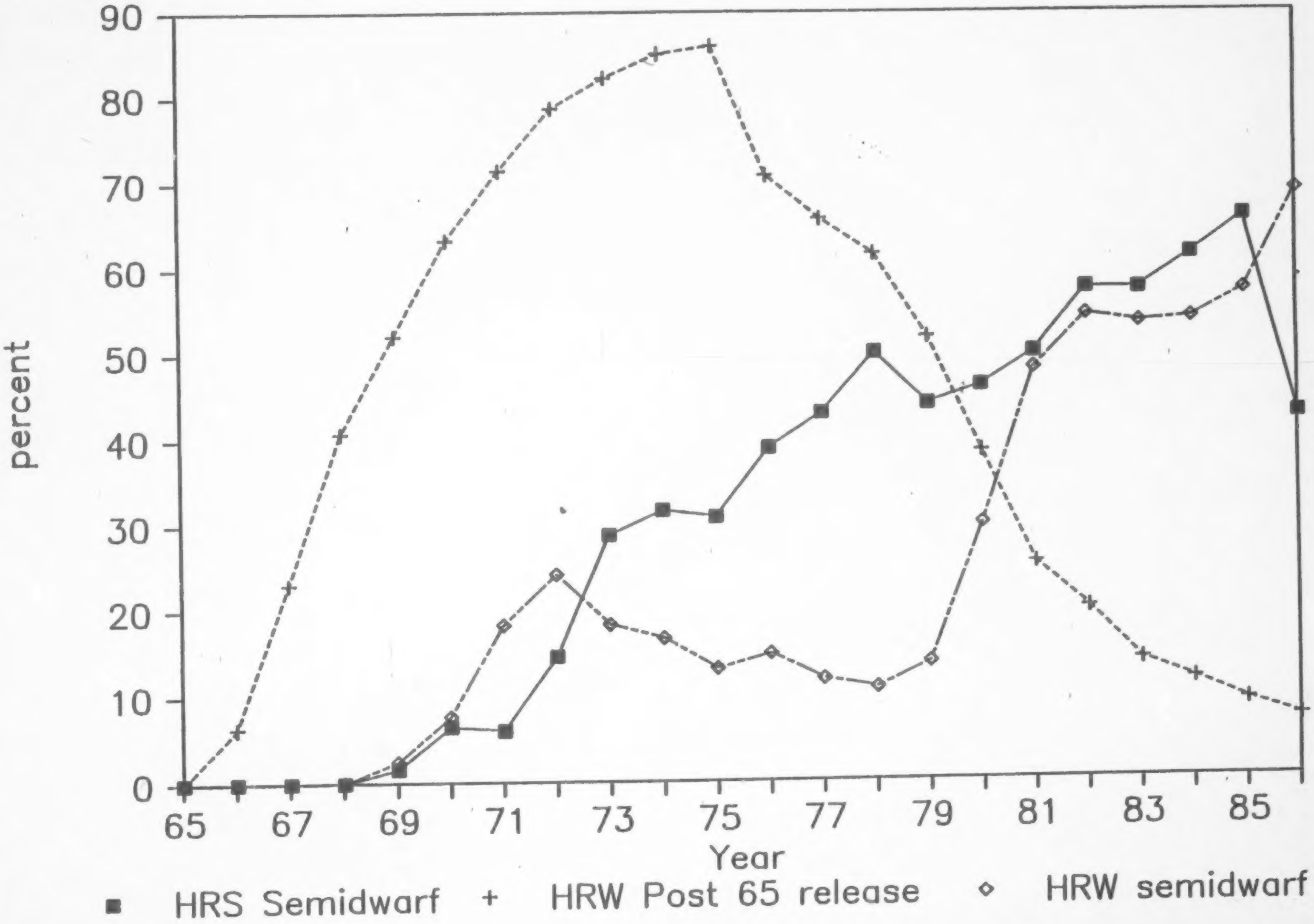

Figure 5. HRW and HRS Percent of Area Planted to Variety Groups

after 1975 represent semi-dwarf varieties. Varieties released after 1965 increased in the percent of acres planted through 19 6 and then decreased being replaced to some extent by semi-dwarf varieties.

The inverse relationship between yield and protein is important to producers decisions on variety selection, and consequently, on crop quality. In the remainder of this section this trade-off is evaluated, first using time series data, then using cross-sectional data. One way to evaluate this trade-off is through a regression analysis using crop average time series data.

A regression was estimated over two time periods, 1965 through 1976 and 1977 through 1986, to determine the average yield protein trade-off in North Dakota and Kansas. The general equation is represented as:

$$Y_t = \beta_0 + \beta_1 \rho_t$$

where

Y_t = state average yield in year t

ρ_t = state average protein level in year t

Separate models were estimated for each state. Regression results are shown in Table 9. Both HRW and HRS show an increase in intercept and slope from the earlier time period to the more recent time period.

TABLE 9. ESTIMATED PROTEIN YIELD TRADE-OFF FOR HRS AND HRW, 1965 TO 1976 AND 1977 TO 1986

Time Period	Wheat Class	Intercept		Protein (ρ)		R^2
1965-1976	HRS	103.68	(6.24)[a]	-5.45	(-4.72)	.66
1977-1986	HRS	148.17	(2.71)	-8.47	(-2.19)	.30
1965-1976	HRW	97.69	(3.62)	-5.87	(-2.56)	.34
1977-1986	HRW	123.83	(5.73)	-7.47	(-4.15)	.64

[a] t-ratios in parenthesis.

The slope coefficient (protein) indicates the number of bushels forgone to increase protein by 1 percentage point. Alternatively, it indicates the aggregate opportunity cost of increasing protein, measured in terms of yield. Thus, in the early time period in Kansas, an increase of 1 percentage point of protein would reduce yield by 5.87 bu/acre. In the latter period this opportunity cost increased to 7.47 bu/acre. Similar results, but a slightly greater change occurred in North Dakota. Thus, in both states the opportunity cost of maintaining a certain level of protein has increased in recent years.

The average protein content for HRW in Kansas from the crop production summary and HRS protein content in North Dakota for experiment station trials is shown in Appendix B. Protein content between North Dakota varieties varies more than that in Kansas wheat varieties, indicating a greater choice between protein levels for producers in North Dakota. The technological change in wheat breeding can be measured in the adoption of newly released wheat varieties by producers. The change in wheat breeding has concentrated on increasing yield and disease resistance. Surveys are conducted in North Dakota almost annually and in Kansas annually to determine the amount of wheat acres planted by each variety available (North Dakota State Wheat Commission) (Kansas Wheat Commission). Percent of acres planted to wheat by variety are shown in Appendix B for Kansas and North Dakota. Note, some years are missing for North Dakota as surveys were not taken in these years. Over time some varieties are adopted and become a substantial part of acreage planted, remaining strong for many years as in the case of the variety Scout in Kansas and Waldron in North Dakota. Other varieties are never adopted to great extent and are only planted in a few years.

The cross-section estimates of yield-protein trade-offs for North Dakota and Kansas are based on three-year average yields and protein levels for available varieties. The most recent period for which data was available was used in each case: 1983 to 1986 for North Dakota and 1978 to 1980 for Kansas. Table 10 presents the dominant varieties planted in each state along with the experiment station yields and proteins.

TABLE 10. AVERAGE EXPERIMENT STATION YIELD AND PROTEIN LEVELS BY VARIETY FOR NORTH DAKOTA AND KANSAS

Variety	Yield	Protein
Kansas		
Payne*	54.0	12.7
Tam 101*	54.3	12.6
Lindon*	54.7	12.1
Newton*	57.0	12.1
Vona*	57.0	11.8
Bennet	51.7	12.7
Sage	50.3	12.7
Cheney	51.3	12.5
Buckskin	51.7	12.3
Larned	52.0	12.2
Centurk 78	53.0	12.2
North Dakota		
Alex	47.90	15.45
Butte	48.40	15.10
Challenger*	47.40	14.50
Columbus	44.10	16.30
Guard*	48.95	14.65
Len*	46.70	15.50
Marshal*	49.90	14.60
PR2369*	50.50	14.80
Stoa	51.90	15.40
Wheaton*	52.30	14.30

*Indicates semi-dwarf.

Yield and protein levels for these varieties are plotted in Figures 6 and 7. Casual inspection suggests an inverse relationship in both Kansas and North Dakota. Also, semi-dwarf varieties are distinguished from other varieties. In Kansas trials, there appears to be an outward shift in the trade-off. In contrast, the semi-dwarfs appear to extend the existing yield-protein line in North Dakota.

Regression results presented in Table 11 confirm the negative relation between yield and protein--estimated protein coefficients are negative and statistically significant for both states. Also, the null hypothesis of one regression line for all varieties was considered against the alternative hypothesis of unique regression lines for semi-dwarf and other varieties. F-statistics calculated from regression squared errors suggest that the null hypothesis be rejected for Kansas trials but accepted for North Dakota trials.[7] Thus, there is a shift in the trade-off for Kansas trials and an extension of the existing trade-off for North Dakota.

TABLE 11. ESTIMATED CROSS-SECTIONAL YIELD PROTEIN TRADE-OFF FOR HRS AND HRW

State	Intercept	Protein	R^2
North Dakota	89.47 (5.30)[a]	-2.70 (2.40)	.43
Kansas			
Semi-dwarf varieties	95.48 (6.30)	-3.27 (2.60)	.70
Other varieties	86.84 (5.60)	-2.83 (2.30)	.56

[a] t-ratios in parenthesis.

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[7] For Kansas (F2,11)=20.3 for North Dakota, F(2,6)=1.5 and F.05(2,6)= 5.14.

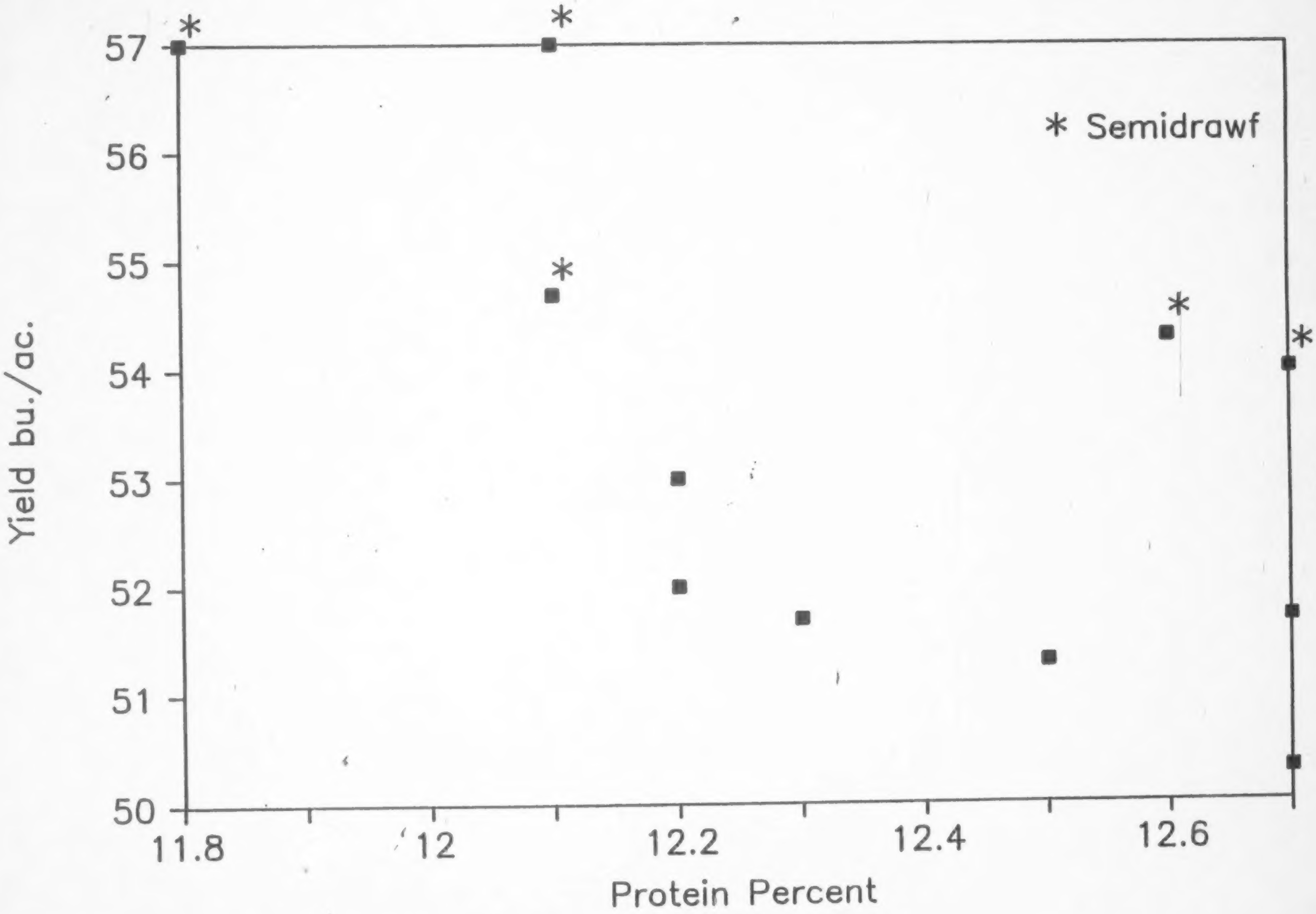

Figure 6. Average Protein Yield Trade-off by Variety KS Experiment Station Trials 1978-1980

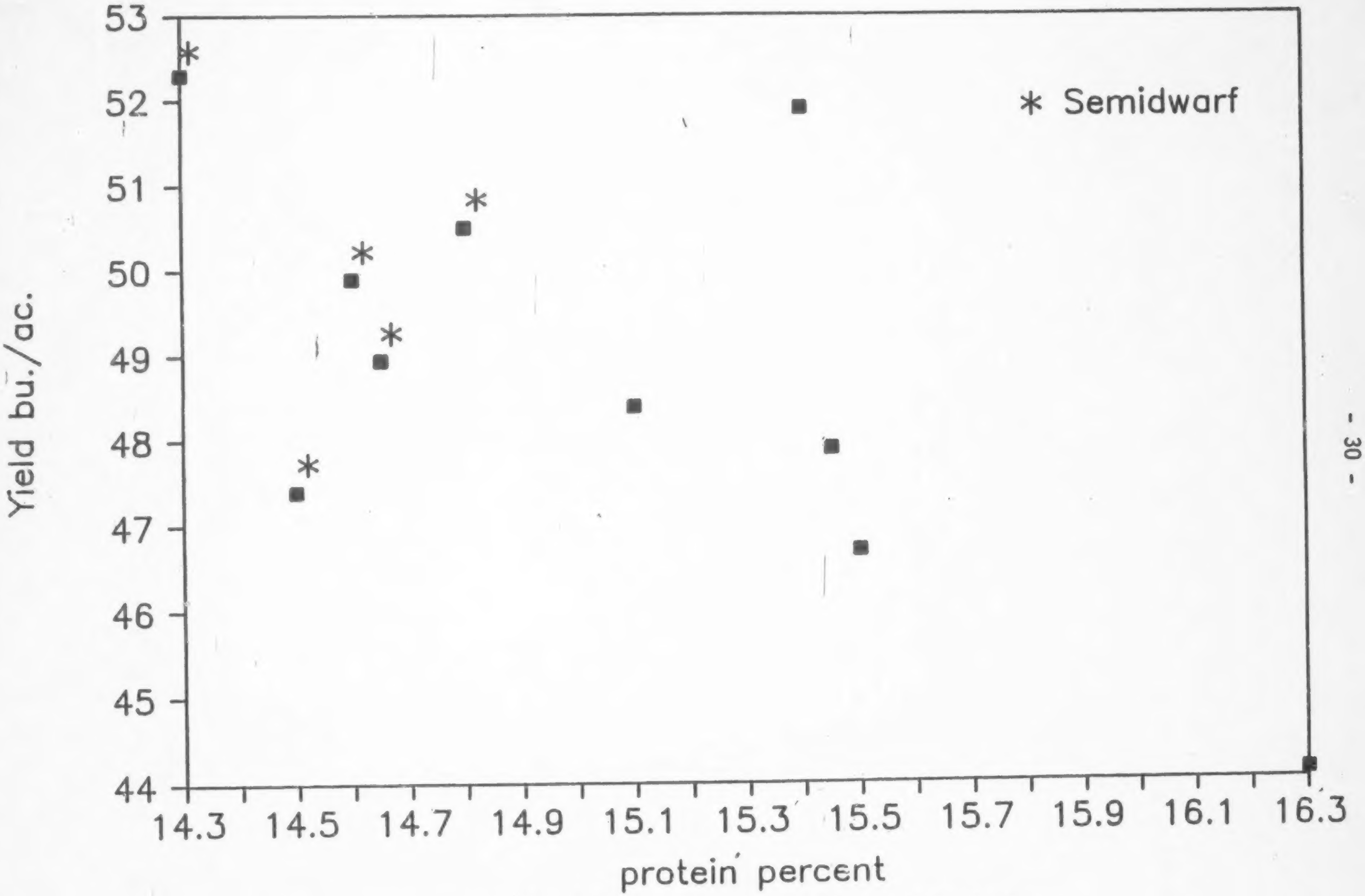

Figure 7. Average Protein Yield Trade—off by Variety
ND Experiment Station Trials 1983—1986

The cross-section and time series results provide two manifestations of the same agronomic principle. Yield increases and protein sacrifices occur when the grain formation period of plant growth is extended. The field trial averages show the effects of genetic variation in this plant growth phase. The state averages show the influence of year-to-year change in weather conditions.

IV. Farm Budgets and Government Programs

One of the impacts of farm programs is that they may distort producer's choices regarding variety selection. Given an inverse relationship between yield and a quality characteristics, protein in this case, any farm program not adequately discounting for quality deviation will have an effect on agronomic practices. In this section a simple budget analysis of the impacts of loan rate protein premiums and deficiency payments is presented.[8] Typical producer situations are posed for both a North Dakota and Kansas wheat producer covering the period 1965 to 1986.

The measure used in this analysis is total revenue. Costs per acre are assumed the same across varieties. Protein premiums used in the analysis were the market premium and the premium paid by the loan rate program. The premiums used in the analysis for HRS were the government loan rate premium and the market premium for 14 percent and 15 percent protein. HRW premiums used were for 13 percent and 11 percent protein. Government program impacts were incorporated into the analysis in that target price was used to calculate total revenue instead of market price. This assumes 100 percent participation in government programs. Yield used in the analysis was 30 bu/acre for HRS 14 percent protein and 25 bu/acre for HRS 15 percent protein in order to reflect a typical yield protein trade-off. Yield for HRW used was 35 bu/acre for 13 percent protein, and 41 bu/acre for 11 percent protein. Total revenue was calculated by adding the market protein premium or government premium to target price and multiplying this sum by the yield per acre.

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[8] A more comprehensive analysis is presented in Section V.

The results are presented in Tables 12 and 13 for North Dakota and Kansas. Total revenue under the market premium condition and the government premium condition are relatively similar to each other except for two brief periods. The mid 1970s and 1980s where market premiums were much higher than government premiums hence, total revenue under the market premium condition is greater than total revenue under the government premium.

Of particular interest is the revenues per acre achievable under the loan program. The farm programs have always favored higher yielding wheats but the difference increased during the 1980s (Figure 8). In 1969 the difference in North Dakota was $9/acre, in 1979 it was $2/acre. However, since then the spread favoring production of higher yielding wheats has increased to $20/acre. Similar results were observed in Kansas.

The impacts of shifts toward use of higher yielding varieties forces the market premium to increase in order to achieve a certain level of protein. To analyze the potential impacts, the producer budgets above were solved under various yield scenarios in order to determine the protein premiums necessary for a producer to be indifferent between high and low yielding wheat. In the case of North Dakota, the total revenue was equated to $144/acre which corresponds with production of 30 bu/acre and 14 percent protein in Table 12. Results were shown in Table 14 for various yield levels, but in each case protein was 15 percent and total revenue was constrained to $144/acre. For

TABLE 12. THEORETICAL REVENUE FOR A ONE-ACRE FARM IN NORTH DAKOTA

		25 bu/acre/15% Protein				30/bu/acre/14% Protein			
		Protein Premium		Revenue Per Acre		Protein Premium		Revenue Per Acre	
Year	Target Price[a]	Market	Loan Rate	Market[b]	Loan Rate[c]	Market	Loan Rate	Market[b]	Loan Rate[c]
	-----------$/bu	-----------		------$/acre-------		------$/bu-------		-------$/acre------	
1965	1.69	0.11	0.105	45	45	0.060	0.075	53	53
1966	1.84	0.01	0.105	46	49	0.010	0.075	56	57
1967	1.73	0.04	0.105	44	46	0.040	0.075	53	54
1968	1.80	0.22	0.105	51	48	0.100	0.075	57	56
1969	1.89	0.17	0.105	52	50	0.070	0.075	59	59
1970	2.00	0.12	0.105	53	53	0.020	0.075	61	62
1971	1.79	0.16	0.105	49	47	0.150	0.075	58	56
1972	1.72	0.08	0.105	45	46	0.080	0.075	54	54
1973	1.47	0.12	0.105	40	39	0.120	0.075	48	46
1974	1.37	0.69	0.105	52	37	0.530	0.075	57	43
1975	1.37	0.98	0.105	59	37	0.710	0.075	62	43
1976	2.25	0.36	0.105	65	59	0.230	0.075	74	70
1977	2.90	0.19	0.160	77	77	0.110	0.090	90	90
1978	2.87	0.11	0.160	75	76	0.035	0.090	87	89
1979	2.50	0.16	0.160	67	67	0.010	0.090	75	78
1980	3.30	0.50	0.160	95	87	0.220	0.090	106	102
1981	3.65	0.14	0.160	95	95	0.060	0.090	111	112
1982	4.50	0.18	0.160	117	117	0.090	0.090	138	138
1983	4.30	0.20	0.160	113	112	0.150	0.090	134	132
1984	4.45	0.53	0.160	125	115	0.300	0.090	143	136
1985	4.38	0.74	0.160	128	114	0.420	0.090	144	134
1986	4.38	0.78	0.160	129	114	0.430	0.090	144	134

[a] Prior to 1973 target price is blended average price to program participants reflecting national average price received by farmers and the marketing certificate value averaged for participant's total production. Post 1973 target prices is loan rate plus deficiency payment.

[b] Revenue is market premium plus target price times yield.

[c] Revenue is government premium plus target price times yield.

SOURCE: USDA, Statistical Reporting Service, "Agricultural Statistics," various issues.

TABLE 13. THEORETICAL REVENUE FOR A ONE-ACRE FARM IN KANSAS

		35 bu/acre/13% Protein				41/bu/acre/11% Protein			
		Protein Premium		Revenue Per Acre		Protein Premium		Revenue Per Acre	
Year	Target Price[a]	Market	Loan Rate	Market[b]	Loan Rate[c]	Market	Loan Rate	Market[b]	Loan Rate[c]
	-----------$/bu	-----------	-----------	------$/acre-------		------$/bu-------		-------$/acre------	
1965	1.69	-0.02	0.0450	58	61	--	--	69	69
1966	1.84	0.05	0.0450	66	66	--	--	75	75
1967	1.73	0.03	0.0450	62	62	--	--	71	71
1968	1.80	0.17	0.0450	69	65	--	--	74	74
1969	1.89	0.03	0.0450	67	68	--	--	77	77
1970	2.00	0.15	0.0450	75	72	--	--	82	82
1971	1.79	0.06	0.0450	65	64	--	--	73	73
1972	1.72	0.05	0.0450	62	62	--	--	71	71
1973	1.47	0.08	0.0425	54	53	--	--	60	60
1974	1.37	0.44	0.0425	63	49	--	--	56	56
1975	1.37	0.42	0.0450	63	50	--	--	56	56
1976	2.25	0.31	0.0450	90	80	--	--	92	92
1977	2.90	0.09	0.0450	105	103	--	0.005	119	119
1978	2.87	0.03	0.0450	102	102	--	0.005	118	118
1979	2.50	0.09	0.0450	91	89	--	0.005	103	103
1980	3.30	0.05	0.0450	117	117	--	0.005	135	136
1981	3.65	0.03	0.0450	129	129	--	0.005	150	150
1982	4.50	0.19	0.0450	164	159	--	0.005	185	185
1983	4.30	0.32	0.0450	162	152	--	0.005	176	177
1984	4.45	0.19	0.0450	162	157	--	0.005	182	183
1985	4.38	0.29	0.0450	163	155	--	0.005	180	180
1986	4.38	0.22	0.0450	161	155	--	0.005	180	180

[a] Prior to 1973 target price is blended average price to program participants reflecting national average price received by farmers and the marketing certificate value averaged for participant's total production. Post 1973 target prices is loan rate plus deficiency payment.

[b] Revenue is market premium plus target price times yield.

[c] Revenue is government premium plus target price times yield.

SOURCE: USDA, Statistical Reporting Service, "Agricultural Statistics," various issues.

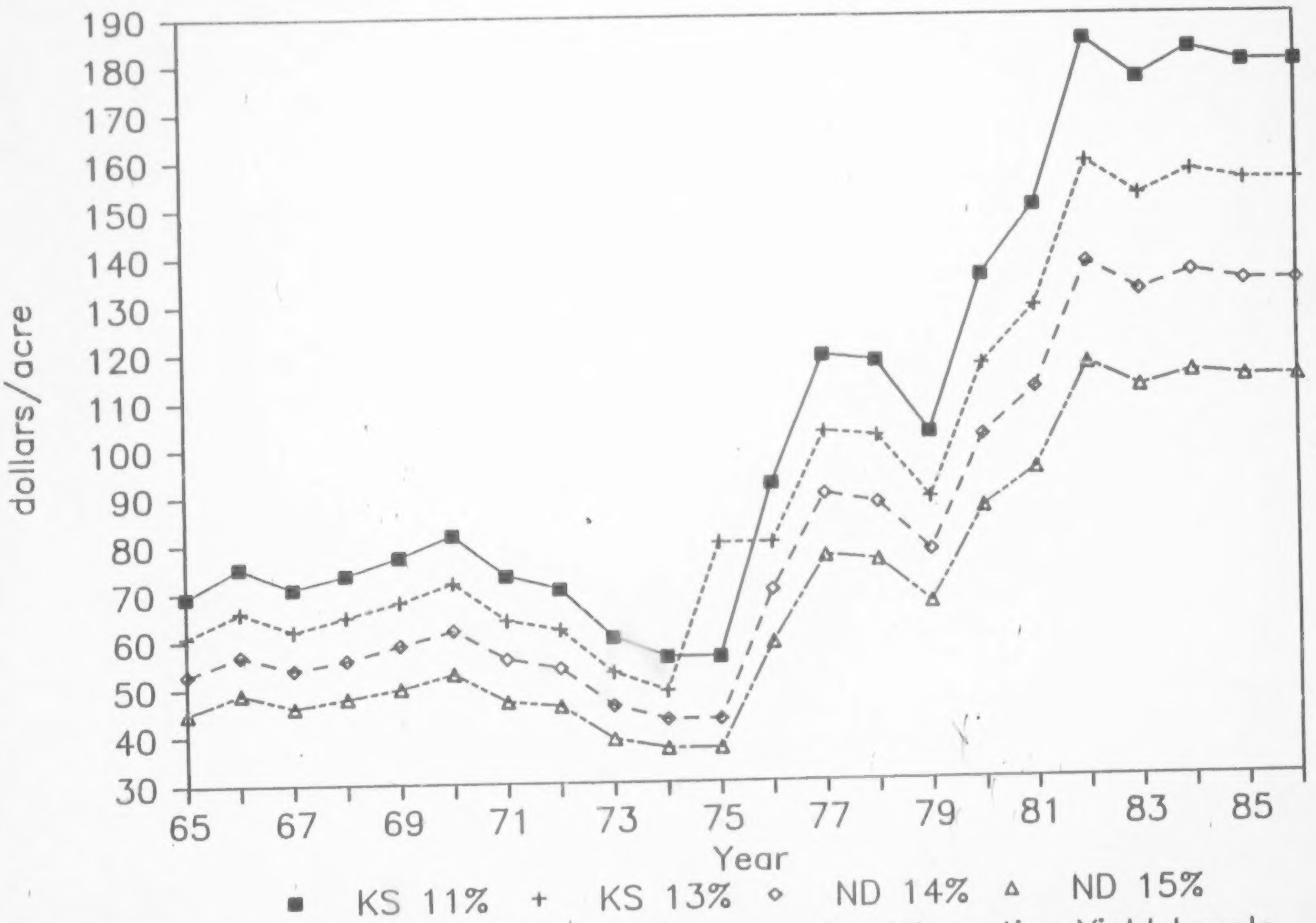

Figure 8. Theoretical Revenue Per Acre for Alternative Yield Levels for ND and KS Producers Using the Loan Rate Premium

TABLE 14. IMPLIED PREMIUM NECESSARY FOR HRS PRODUCERS TO BE INDIFFERENT BETWEEN GROWING 14 PERCENT AND 15 PERCENT PROTEIN WHEAT

Yield	Protein	Premium[b]	Loan Rate	Revenue[a]
bu/acre	%	$/bu	$/bu	$/acre
29	15	0.53	2.40	144
28	15	0.64	2.40	144
27	15	0.75	2.40	144
26	15	0.87	2.40	144
25	15	1.00	2.40	144

[a] Revenue (TR) was derived as

$$TR = Y_p \cdot DP + (Y_a \cdot P_0) + Y_a \cdot Premium$$

where Y_p is proven yield (30 in this case), DP is the deficiency payment, Y_a is actual yield (29. . .25), P_0 is market price or loan rate.

[b] Premiums are derived from equating TR to $144/acre.

example, if a producer could achieve an increase of 1 percent protein, with a decrease in yield of one bu/acre, the premium necessary to equate $144/acre is 53 cents/bu per 1 percent protein. A more realistic situation is where three bu/acre would be foregone to increase protein 1 percent. In this case the protein premium would have to increase to 75 cents/bu per 1 percent of protein.

The protein premium needed to neutralize a producer's decision to produce 14 percent or 15 percent protein wheat increases as the yield difference between 14 percent protein and 15 percent protein increases. This is caused by the target price deficiency payment program which pays a producer $1.98/bu more than the market. This indicates the opportunity cost of decreasing yield and increasing protein is $4.38 (target price). This creates a high protein premium needed to render a producer indifferent between producing 14 and 15 percent protein wheat. Results are shown in Table 15 for HRW wheat in Kansas. Comparisons are made in production of 41 bu/acre and 11 percent protein. Results are similar to those of HRS.

TABLE 15. IMPLIED PREMIUM NECESSARY FOR HRW PRODUCERS TO BE INDIFFERENT BETWEEN GROWING 11 PERCENT AND 13 PERCENT PROTEIN WHEAT

Yield	Protein	Premium[b]	Loan Rate	Revenue[a]
bu/acre	%	$/bu	$/bu	$/acre
39	13	0.10	2.40	179
37	13	0.22	2.40	179
35	13	0.34	2.40	179
33	13	0.47	2.40	179
31	13	0.59	2.40	179

[a] Revenue (TR) was derived as

$$TR = Y_p \cdot DP + (Y_a \cdot P_0) + Y_a \cdot \text{Premium}$$

where Y_p is proven yield (41 in this case), DP is the deficiency payment, Y_a is actual yield (39. . .31), P_0 is market price or loan rate.

[b] Premiums are derived from equating TR to $179/acre.

V. Producer Response to Markets, Farm Programs, and Technology

This section examines the extent of, and potential for adjustment in wheat protein content to profit incentives. First, a conceptual discussion of producers' output and quality decisions is presented. Then time series protein data for Kansas and North Dakota are examined for evidence of adjustment in quality in response to changing market conditions. Thereafter, the yield-protein trade-offs, limits on protein choice, and market incentives are evaluated for an assessment of the potential for adjustment to economic conditions. In the final section, the impact of farm program prices on optimal protein decisions is evaluated.

Conceptual Presentation

Producers choose application rates for inputs such as fertilizer and select seed varieties. These choices have potential to affect both the volume and quality of output. To wit, fertilizer typically increases yield and a seed variety with high average protein has low average yield, but producers must cope with the uncertainties of biological production processes. For instance, fertilizer may not improve yields if rainfall is low, and hot weather can increase protein content regardless of the seed variety.

An ideal analysis of quality incentives would take the producers decisions and random environmental influences into account. In particular, the full production process might be presented as

$$y=f(F,s) + \varepsilon_y \text{ and } \rho = \bar{\rho}_1 + \varepsilon_\rho$$

where ε_y and ε_ρ represent the random environmental influences on yield (y) and protein content (ρ). The function, $f(F,s)$, indicates the relation between producer's decisions and yield. Fertilizer (F) increases yield, and seed selection (s) also influences yield through the yield/protein trade-off. Seed selection (s) is a vector with zero values unless seed variety (i) is the producer's selection: $s=[0,..,0,1,0,..,0]$. In the second equation above, $\bar{\rho}_i$ is the average protein content of seed selection i, and actual protein realized depends on the seed selection as well as environmental influences.

This view includes all dimensions of the producer's decision. However, implementation is impossible because data is not available. A full analysis including risk dimensions could be conducted if SRS yield surveys included yield and protein by variety. The interim analysis outlined below excludes environmental effects but illustrates how profit incentives could work to influence protein levels.

Suppose the relationship can be summarized by a production-characteristic function: $y=f(F,\rho)$. In this equation yield and fertilizer are positively related because soil nutrients stimulate grain production. Also, yield and protein are inversely related because of the yield protein trade-off.

Protein content is assumed to determine the price received for the product $(P(\rho)$. In Figure 9 a positive relation between protein level and price is indicated. P_0 indicates the price for some base level of protein, such as 11 percent protein winter wheat. This figure illustrates that higher protein wheats command higher prices. The position and shape of this premium schedule varies from year-to-year as market conditions change.

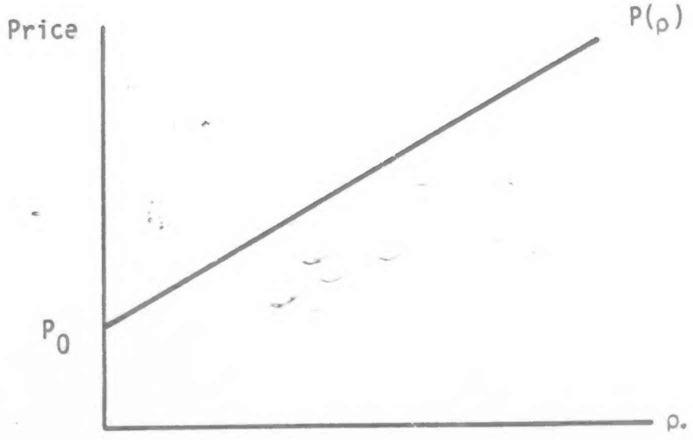

Figure 9. Relationship Between Protein Level and Protein Price

The producer would resolve conflicts between incentives and trade-offs by examining the contribution of small changes in fertilizer and protein content to profits.[9] The producers' profits π are the difference between revenues and expenditures on fertilizer. Profits can be expressed in terms of premium schedules and the production function as

$$\pi = P(\rho)y(F,\rho)-P_F F$$

where P_F indicates the price of fertilizer. The contribution of an additional unit of fertilizer is the value of the marginal product less the price of fertilizer, or

$$P(\rho) \frac{\partial y}{\partial F} - P_F$$

Thus, fertilizer can no longer increase profits when the value of the marginal product equals the fertilizer price. The profit contribution of a one point increase in protein consists of a revenue gain from the higher price and a revenue loss from reduced yields:

$$P(\rho) \frac{\partial y}{\partial \rho} + \frac{\partial P}{\partial \rho} y$$

Profits can no longer be increased when the revenue gain and loss offset each other. This condition is equivalent to the condition that the percentage yield loss associated with a protein increase equals the percentage price gain from the protein increase

$$- \frac{\partial y}{\partial \rho} /y = \frac{\partial P}{\partial \rho}/P \text{ or } 1(\rho) = g(\rho)$$

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[9] For a more detailed presentation, see Appendix C.

The producers' protein choice is illustrated in Figure 10. The yield loss function is upward sloping, reflecting the reduced yields which accompany protein increases. The shape of the percentage price gain function depends on the characteristics of the price-premium schedule but we expect that it is a downward sloping function of protein content. The producer chooses protein level ρ* in Figure 10, where the percentage price gain and yield loss are equal.

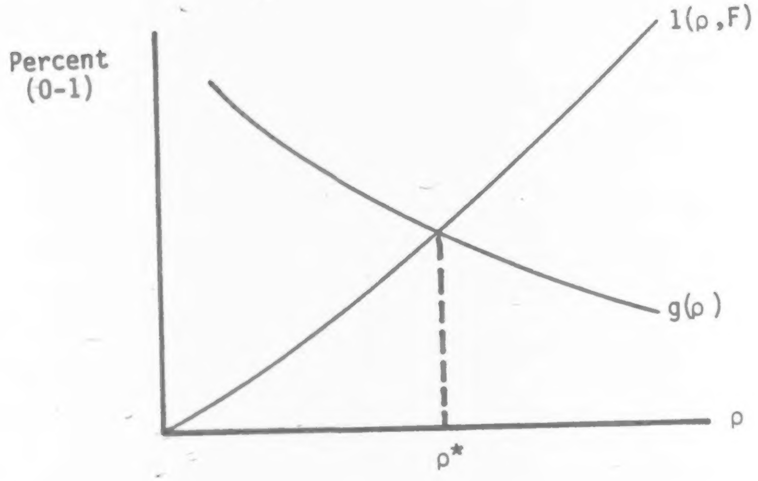

Figure 10. Producer's Desired Protein Level

Changing market conditions could give producers incentives to adjust their desired protein level. Direct quality incentives increase when g(ρ) shifts rightward because of a price level reduction, a higher nominal protein premium, or both. Then producers increase desired protein and sacrifice yield along the trade-off schedule. Indirect quality incentives increase when profits call for more inputs (fertilizer). An increase in the relative wheat-fertilizer price encourages farmers to use more fertilizer and increase yield. This outward shift in the yield-protein trade-off shifts the percentage yield loss schedule in Figure 10 downward and results in an increase in the desired protein level.

Testing for Protein Response to Changing Economic Conditions

The theory developed above shows how profit-seeking producers would respond to protein premiums and prices. The purpose of this section is to evaluate the extent that producers actually have adjusted protein choices to changes in economic incentives. Statewide aggregate data are analyzed in both Kansas and North Dakota. Testing allowed for economic and technical influences or desired protein levels. The equation below is representative of relationships considered

$$\rho^*_t = \alpha + \beta g_{t-1} + \gamma \frac{P_{t-1}}{F_t} + \delta T$$

In the above equation ρ is the desired protein level in a particular state (Kansas or North Dakota). Direct quality incentives are represented by g. The percentage protein premium for a one point protein increase g is lagged one year because producers make production decisions at the time they observe premiums from the previous marketing year. The relative wheat/fertilizer price (P/PF) represents indirect quality incentives--this variable was also lagged to account for production delays. A time trend was included as a surrogate for technical change; new varieties may be adopted which have different protein levels from earlier varieties. To the extent that these varieties are adopted for reasons other than protein levels, there could be secular movements in proteim levels which are not explained by economic variables.

To approximate producers' desired protein level, a "protein score" was derived for each state.[10] The protein score reflects the average protein level of a particular variety and the proportion of area planted to these varieties but excludes weather effects. Protein scores were constructed as follows. The mean protein level for a particular variety was calculated as an acreage-weighted average of variety means.[11] The protein scores for Kansas and North Dakota calculated in this fashion are shown in Table 16. Notice that the time series is short in both cases. Also, variety surveys were not conducted in four years in each state because only 13 years of protein score data was available, only the most rudimentary testing for protein response was performed.

Economic variables were measured with readily available market information. The percentage protein premium for a one point protein increase (g) was constructed from protein premiums and base-grade prices in Minneapolis and Kansas City markets. Season average farm prices in Kansas and North Dakota were used as the numerator in the wheat-fertilizer price ratio. A nitrogen price series was used for the fertilizer price.[12]

Preliminary regressions confirm a statistically significant downward trend in protein scores for Kansas and North Dakota. However, results for the response to economic incentives were mixed. Neither the protein premium nor wheat-fertilizer ratio were statistically significant and both had incorrect

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[10] Some preliminary regressions used actual state average protein content. See Appendix E.

[11] Data used in the construction of these indices and sources are given in Appendix B.

[12] These data are given in Appendix Table D2.

TABLE 16. PROTEIN SCORES FOR KANSAS AND NORTH DAKOTA, 1970 TO 1986

Year	Kansas	North Dakota
1970	--*	15.12
1971	--*	15.32
1972	--*	15.25
1973	--*	15.21
1974	11.73	15.19
1975	11.71	15.19
1976	11.78	--*
1977	11.81	--*
1978	11.82	15.17
1979	11.83	14.92
1980	11.77	14.91
1981	11.72	--*
1982	11.74	15.10
1983	11.70	--*
1984	11.61	14.90
1985	11.62	14.81
1986	11.68	15.09

*No surveys were conducted during these years.

signs for Kansas. In contrast, North Dakota results suggest a moderate or occasional response to market premium incentives but the wheat fertilizer ratio was not significant.

The estimated relation between the Kansas protein score and trend is typical of these estimations

$$\rho k_t^* = \underset{(239.3)}{11.855} - \underset{(2.6)}{.01115T}$$

$\bar{R}^2 = .384$ D.W. $= .73$ $\bar{s} = .057$

Historical Period: 1974-86

where

ρk_t^* = Kansas protein score, in percent (0-100)

T = 1 in 1970, 2 in 1971, ..., 17 in 1986

North Dakota results which suggest a negative relation between protein score and trend are shown below:

$$\overset{*}{pn}_t = \underset{(229.9)}{15.26} + \underset{(1.3)}{1.8038}\; gn_{t-1} - \underset{(3.9)}{.02318T}$$

$\bar{R}^2 = .527$ D.W. = 2.03 $\bar{s} = .1079$

Historical Period: 1970-75, 1978-80, 1982, 1984-86

where

$\overset{*}{pn}_t$ = North Dakota protein score in percent (0-100)

gn_{t-1} = percentage increase in price from 1 percent increase in protein

As a variation on this basic specification, it was assumed that response occurs only if premiums are above the mean. This specification produced a moderate improvement in the results.

$$\overset{*}{pn}_t = \underset{(253.5)}{15.30} + \underset{(1.6)}{3.052}\; (gn_{t-1}-\overline{gn})*D_t - \underset{(4.1)}{.0251T}$$

$\bar{R}^2 = .560$ D.W. = 2.07 $\bar{s} = .164$

Historical Period: 1970-75, 1978-80, 1982, 1984-86

where

$$D_t = \begin{cases} 1, \text{ if } gn > \overline{gn} \\ 0, \text{ if } gn < \overline{gn} \end{cases} \qquad \overline{gn} = \text{mean value of protein incentive}$$

Overall, these results suggest only a small and occasional protein response to market incentives. In North Dakota, a change in the protein premium from historical minimum to maximum results in a 0.3 percentage point change in the average protein content. There is no evidence of any protein response in Kansas, regardless of the methodology employed.

Protein response to market incentives may be small or nonexistent because of several factors. First, producers' control is indirect and subject to the environment or producers' assessment of profit consequences may be incomplete due to a lack of information. Also, there is only a narrow range of protein choices available in both regions, so producers may be unable to adjust. Finally, local marketing practices may account for the lack of response in Kansas. North Dakota elevators routinely test for and pay on the basis of protein content whereas Kansas elevators typically pay on a station average basis.

A secular decline in protein content, between 0.2 and 0.5 percentage points, has occured in Kansas and North Dakota during recent decades. This decline coincides with the adoption of new generations of technology; semi-dwarf varieties released since the 1970s have included varieties with lower protein levels than those that were previously available. In the final analysis, producers' choice among varieties include several factors in addition to protein content, such as yield advantage and disease resistance. These other factors may be the primary factors influencing seed selection. Decisions about yield advantage and disease resistance may have implications for protein levels but it does not appear that protein incentives have a strong influence on the average protein content of the Great Plains wheat crop.

Potential for Adjustment in Protein Levels

In this section the extent of balance between profit incentives and protein levels is examined, then it is possible to consider the influence that government policies, such as support prices, ASCS protein premiums, or regulations requiring protein measurement, at the farm level, could have if adjustment barriers are overcome. First, the impact on producers of a limited range of protein level alternatives is examined. Then calculations of profit-maximizing protein choices are presented. These calculations are based on experiment station estimates of yield-protein trade-offs, the observed range of prices and premium schedules in Kansas City and Minneapolis markets, and econometric estimates of yield response to prices.

When producers choose among alternative methods of increasing output, they will choose the input or characteristic that delivers the outpout with the lowest marginal cost. Furthermore, the principle of diminishing returns sets in when producers have a full range of choices, so the marginal cost is the same for all methods of output expansion. In the fertilizer-protein problem, the marginal costs of increaseing output through a protein reduction and a fertilizer increase both equal the product price for a profit-maximizing producer:

$$-\frac{\partial P}{\partial \rho}\frac{\partial \rho}{\partial y}\,y = \frac{P_F}{\partial y/\partial F} = P(\rho)$$

The marginal cost of additional output with fertilizer is the ratio of the fertilizer price and its marginal product

$$\left(P_F/\frac{\partial y}{\partial F}\right)$$

The marginal cost of increasing output through a protein reduction is an opportunity cost; the revenue loss associated with the quality reduction.

This cost can be expressed as the product of the price loss associated with the yield increase times the current yield level

$$\left(\frac{\partial P}{\partial \rho} / \frac{\partial y}{\partial \rho}\right) \cdot y$$

Both marginal costs are equal to the price the producer receives for output, which depends on the protein content of the product $P(\rho)$.

Figure 11 depicts the relationship among marginal costs, product prices, and protein levels. The marginal cost of increasing output with a quality reduction (MC^1) generally declines with higher protein levels because of yield losses associated with protein increases. Also, the position of this curve reflects the yield-protein trade-off and the slope of the price-premium schedule; generous protein premiums shift the curve upward (MC^2) because the cost of reducing quality is high. Similarly, a high percentage yield loss from a protein increase reduces the cost of quality reduction and shifts the curve downward (to MC^0). The price line, $P(\rho)$ reflects a market or government premium schedule, and it is assumed that fertilizer is adjusted to the point where the marginal cost of fertilizer (MC_f) equals the product price. In the case where the price premium schedule defines MC^1 a protein level is chosen (ρ_1) that equates the marginal cost of reducing protein and the product price.

Limited protein choice and the absence of diminishing returns may preclude full adjustment. Returning to Figure 11, suppose that ρ_0 and ρ_2 define the minimum and maximum protein choices that are available. If the price-premium and percentage yield loss define the curve MC^0, the marginal cost of increasing output by protein is always less than the marginal cost of increasing output with fertilizer, so the producer adjusts the protein level down to the minimum available level (ρ_0). Similarly, when the marginal cost of reducing protein exceeds the product price for all available protein choices, the producer increases protein up to the maximum available ρ_2. These constraints may exist due to restrictions on breeding programs.

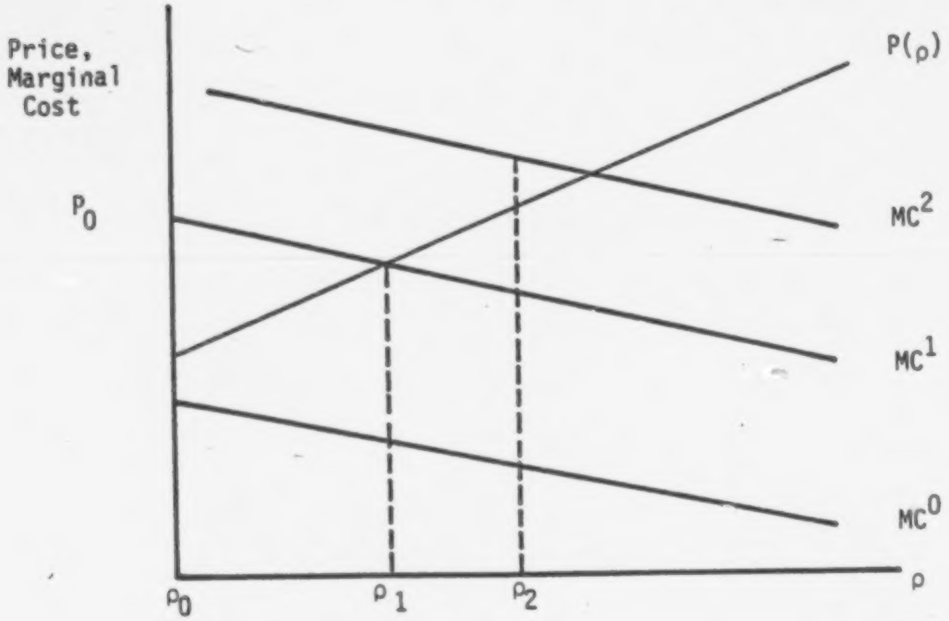

Figure 11. Equilibrium Protein Levels

Calculations of optimal protein levels for Kansas and North Dakota are based on the requirement that the marginal cost of increasing output by protein reduction is equal to the product price:

$$-\left(\frac{\partial P}{\partial \rho} \Big/ \frac{\partial y}{\partial \rho}\right)y = P(\rho)$$

Numerical estimates of protein choices require several market and technical parameters. First market incentives are based on historical ranges for protein incentives (Table 17), and it is assumed that a linear price-premium schedule is a reasonable approximation:

$$P(\rho) = P_0 + A(\rho - \rho_0)$$

where ρ_0 represents a base protein level and P_0 is the corresponding price.

TABLE 17. SUMMARY OF THE RANGE OF MARKET INCENTIVES FOR HRS AND HRW WHEAT

Market	Minimum	Mean	Maximum	Loan Rate Premiums
	---------- $/bu per one point protein ----------			
Kansas City, average 11.0 to 12.5% protein (1980-85) premium	.008	.088	.164	.010[a]
Minneapolis, average 14.0 to 15.0% protein (1980-85) premium	.050	.200	.350	.053[b]

[a] Calculated per point from 11-12.5 percent protein.
[b] Calculated per point from 12-15 percent protein.

Estimates of the relation between experiment station yields and protein levels for North Dakota and Kansas (Section III) provide an indication of the yield loss associated with protein increases. These estimates provide a constant for approximating

$$\frac{\partial y}{\partial \rho} = - b$$

Because experiment station's yields are higher than actual farm yields in both states, some ambiguity arises as to whether the yield loss is constant on a per bushel or percentage basis. It was assumed that the percentage yield loss is the same at base level protein for experiment station and actual farm yields. Thus, a potentially optimistic assessment of the potential for response is provided. See Appendix D for details.

Finally, results on state average yield response to prices and policies are summarized in Appendix D. These equations were linearized around 1986 levels. Also, it is assumed that these relationships describe the yield response at a constrained minimum protein level, so the trade-off estimate is included to approximate the effects of deviation from minimum protein choice as follows:

$$y = \alpha + \beta P - b(\rho - \rho_0)$$

The marginal cost of protein relations and the profit maximizing protein choices can be obtained as a matter of routine algebra. For reference, these relationships are shown below:

$$\rho - \rho_0 = \frac{Ay_0 - P_0 b}{2Ab}$$

where $y_0 = \alpha + \beta P_0$, and $MC_\rho = \frac{A}{b}[y_0 - b(\rho - \rho_0)]$

Tables 18 and 19 indicate the profit maximizing protein choice for North Dakota and Kansas under various circumstances. The rows of the table indicate nominal protein premiums and the columns indicate the price for a base grade of protein (11 percent winter wheat and 14 percent spring wheat). These price and protein premiums can refer to several marketing alternatives. If the producer sells on the market and no government programs are in effect, the price and premium both reflect market rates. If the producer sells on the

TABLE 18. MAXIMUM PROFIT PROTEIN LEVELS FOR NORTH DAKOTA

Market Premium (Minneapolis Range)	P_0 Price For Basegrade (14 Percent) 2.00	3.00	4.00	5.00
$/bu per percentage point	percent (0-100)			
.05	1.9	-7.5	-16.8	-26.1
.10	11.9	7.5	3.2	-1.1
.15	15.2	12.5	9.7	7.2
.20	16.9	15.0	13.2	11.4
.25	17.9	16.5	15.2	13.9
.30	18.5	17.5	16.5	15.5
.35	19.0	18.3	17.5	16.7

Note: Protein levels outside of the enclosed area generally are not available.

TABLE 19. MAXIMUM PROFIT PROTEIN LEVELS FOR KANSAS

Market Premium (Kansas City Range)	P_0 Price For Basegrade (11 Percent) 2.00	3.00	4.00	5.00
$/bu per percentage point	percent (0-100)			
.025	-21.2	-40.6	-60.0	-79.1
.050	-1.2	-10.6	-20.1	-29.6
.075	5.5	-0.6	-6.8	-12.9
.100	8.9	4.4	-0.1	-4.6
.125	10.9	7.4	3.9	0.4
.150	12.2	9.4	6.6	3.8
.175	13.1	10.8	8.5	6.1

Note: Protein levels outside of the enclosed area generally are not available.

market but receives deficiency payments, the base price refers to the target price and the premium to the market schedule. Finally, if the producer markets the grain by defaulting on a loan, the premium is the ASCS schedule and the price is the target price.

Perusal of the protein choices suggests some sensible producer reactions in an environment of free adjustment. For example, a rising protein incentive would increase the protein choice with a given price level. Meanwhile, increases in price levels with fixed nominal protein returns reduce the protein level because the percentage gain from protein falls.

However, there are some limitations on the range of adjustments because winter wheat producers have choices between the 11 percent to 13 percent range while spring wheat choices range from 13 percent to 16 percent. Consequently, several of the indicated protein choices are not available (indicated by the enclosed area in these tables). Also, indicated protein levels are negative in some extreme cases. These indicate strong incentives to adjust toward low protein/high yields when target prices are high and protein premiums are low.

While the trade-offs facing Kansas and North Dakota producers are similar, the incentive is typically higher in the HRS wheat range than it is in the HRW wheat range. In particular, the protein premiums in the left hand column indicate the range of premiums paid in Kansas City and Minneapolis markets. Consequently, there is a fundamental difference between protein choices in Kansas and North Dakota. In Kansas, the high-profit protein level is available in ranges only at the lowest price levels and the highest protein levels in the lower left hand corner of the table. In contrast, available protein levels for North Dakota correspond to high-profit choices at the average of recent market premiums. However, given recent high support levels ($4.38/bushel) and average market protein premiums, the high profit choice for North Dakota is at or near the bottom of the available protein range.

The above calculations are rough and should be viewed as preliminary. Nonetheless, an imbalance between profit-signals and protein levels is indicated. Limited variety selections may contribute to this imbalance. If these conditions persist, however, it is difficult to access if adjustments would occur or what form they would take.

VI. Conclusions

Farm programs have always played an important role in United States agriculture. Most analyses and comparisons of farm program impacts are on the market, exports, or aggregate income. However, being farm programs do transmit incentives throughout the production marketing system, they have the potential to affect grain quality. There are numerous features of farm programs which continually change through time and which are unique for each crop. There are two provisions of farm programs which are generally applicable. One is the loan rate program with its associated premiums and discounts for deviations from a specified quality. The second is the target price program whose payments are based on yield. To the extent that yield and quality are inversely related, incentives to increase yield put pressure on producers to indirectly reduce quality. The purpose of this report is to analyze the impacts of farm programs on grain quality. The concepts presented are general and should be applicable to any commodity in which premiums and discounts develop in the market, and/or in which there is a yield response to prices and quality is inversely related to yield. The empirical analysis presented in this report is applied to the hard wheat market, specifically hard red winter (HRW) and hard red spring (HRS). These classes were chosen for analysis because premiums and discounts play an important role in the market as does the loan program, and because there is a distinct trade-off between yield and protein level in production.

Data were assembled and reviewed in market and loan rate premiums and discounts. Functional relationships were estimated and used to simulate profit-maximizing choices between yield and protein levels. Important conclusions are:

1) The administration of loan rate values has changed through time. In the 1960s there were too additional premiums/discounts for quality deviations besides those for grade. One was applied to sedimentation values, which is a test for strength of the wheat. The other was a discount for varieties which continued through the early 1970s. The impact of these discounts was to reduce the effective loan rates for particular wheats relative to the feed grain loan rate. Both features were abandoned in current administration of loan rate premiums and discounts.

2) There are substantial differences between loan rate premiums and discounts relative to those of the market. Premiums for protein have nearly always been less than those of the market, and this spread has been increasing in recent years. Likewise, at least in the case of hard red spring wheat, grade discounts are not at all reflective of market discounts. Again, the spread between these has been increasing in recent years. There are two important effects of these discrepencies. First, signals tranmitted via the loan rate spreads do not provide incentives for quality improvement. Second, because of these spreads the loan rate program provides an artificial market for inferior quality wheat and/or wheat with lower protein content. While producers likely do not respond in production decisions to these spreads, there is a response in the allocation of inferior quality wheat. Specifically, inferior quality wheat will have a greater tendency to go under loan and ulimately released over subsequent time periods. As a result, the market becomes distorted and to some extent the incidence of inferior quaity wheat is not reduced as much as if market discounts applied.

3) Premiums for protein have increased to record high levels in recent years due to reductions in protein levels in both HRW and to a lesser extent in HRS.

4) There is a distinct trade-off in production between yield and protein. The results suggest that in recent years this trade-off may be increasing, suggesting that the opportunity cost of maintaining a certain protein level in terms of yield foregone, is increasing. The adoption of semi-dwarf varieties has resulted in an outward shift in the trade-off in HRW. Semi-dwarf adoption for HRS has resulted in an extension along the already existing trade-off.

5) The statistical analysis indicates that there are positive and significant responses in yield to increased prices. However, direct evidence in response of protein levels to premiums is limited. There has been a long-term decrease in the protein level of HRW and HRS and a decrease in protein level due to the adoption of semi-dwarf varieties. In HRS the results suggest a very slight supply response to protein incentives. The likely explanation of these results is that in both states, but especially Kansas, the choice of protein levels available to producers is limited, thereby precluding a response.

6) The impact of the target price program is to provide incentives to increase yields due to the higher price level per bushel. As such, the optimum protein level from a producer perspective decreases as target prices increase. Thus, when target prices increased the incentive for higher yields and therefore lower protein levels increased, resulting in fundamental of pressure to increase protein premiums. In general, the availability of alternative protein level choices in North Dakota is adequate. However that in Kansas is limited, precluding producers from responding to market fundementals.

A combination of environmental and institutional factors may inhibit producer response to protein incentives. Public information, particularly in HRW, about the yield and protein consequences of particular variety selections is not available beyond the experiment station so the profit consequences of seed choices have not been fully assessed. Further, first handling stations in the central plains typically do not apply premiums and discounts to individual producers for protein. Finally, the range of protein choices available to producers is limited and may preclude adjustment. The imbalance between potential incentives and protein choices may persist indifinitely if weather effects are pervasive. On the other hand, improved information and changes in marketing practices could facilitate adjustment.

In commodities such as hard wheats in which the loan rate program is an important feature and in which there are trade-offs between yield and protein, farm programs potentially have important impacts on quality. HRW and HRS are used here for example purposes, but the general principles apply to other commodities. Producers likely do not respond to loan rate premiums and discounts. However, the fact that they are less than market premium and discounts results in a distortion. Most important is that the incidence of inferior quality grain is not reduced. In addition, as opposed to competitive exporters, inferior quality grain is distributed over several subsequent crop years. The target price program has longer term impacts. Incentives are transmitted throughout the production system to increase yields. Transmisssion of signals for producers to breeders and ultimately to variety development is a very long dynamic process. Due to this program there is underlying pressure for reduced protein levels in each market and therefore fundamental pressure on protein premiums. In the past there has been limited response by producers to variability in protein premiums. In some years higher protein levels are desired than achievable, in others, lower levels are desired. In other words, optimum production decisions have been constrained due likely to technology, variety development and release programs in the respective states.

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Appendix A

Statistical Analysis of Protein Premiums

In order to analyze and determine factors influencing protein premiums, an inverse demand function was specified and estimated, from which price flexibilities and elasticities were derived. Procedures and results of this analysis are presented in this appendix. All data were taken from sources described in the text, except the supply data which was taken from selected issues of Wheat Situation.

The following function was specified for the demand for protein.

Structural Equation

$$Q_S^D = F\ (P^S,\ P^W,\ TSS,\ TSW,\ T)$$

$$Q_W^D = F\ (P^S,\ P^W,\ TSS,\ TSW,\ T)$$

where

P^S = HRS protein premium

P^W = HRW protein premium HRW

Q_S^D = Equilibrium quantity of HRS protein

Q_W^D = Equilibrium quantity of HRW protein

TSS = Total supply HRS

TSW = Total supply HRW

T = Trend

Protein demand for a particular class is inversely related to protein premiums of each class. Premiums for the other class are also included to allow for substitutability. TSS and TSW were included to account for their potential influence on protein demand as large supplies of quantity may result in a reduced demand for protein, everything else being the same. In equilibrium protein demand and protein supply are equal, and reduced form equations can be specified because protein supply is predetermined in a particular time period. Following are reduced form equations which were specified as a dynamic partial adjustment model:

$$P_t^S = f(Q_S, Q_W, P^S_{t-1}\ TSS_t, TSW_t, T)$$

$$P_t^W = f(Q_S, Q_W, P^W_{t-1}\ TSS_t, TSW_t, T)$$

where Q_S and Q_W are equilibrium supplies of protein in the spring and winter wheat market, respectively.

The above reduced form equations were estimated and the results presented in Table A1. The results indicate that protein premiums are inversely related to the supply of protein, as well as the total wheat supply of each class, in the two regions, respectively. T-ratios are significant in nearly all cases confirming the statistical significance. Of interest, is that the coefficient for trend is positive and significant in all equations, indicating significant increases in protein premiums through time, possibly due to preferences.

Price flexibilities and elasticities are calculated and presented in Tables A2 and A3, respectively. A price flexibility indicates the percentage change in protein premium in response to a percentage change in protein availability. In all cases the coefficients are highly flexible implying very price inelastic demands as shown in Table A3. The price flexibilities for 15-12 percent protein in HRS for example, indicate that a 1 percent reduction in protein supply (e.g. from 14 to 13.86 percent) in HRS (HRW) would result in an increase in protein premiums between 15 and 12 percent of 9.68 percent (5.54%) in the short-run, and 11.65 percent (6.67 percent) in the long-run. Of interest is that the cross-price flexibilities increase for

TABLE A1. ESTIMATED REDUCED FORM PROTEIN PREMIUM EQUATIONS[1]

	Intercept	Dep t-1	O_S	O_W	TSS	TSW	Trend	R^2
HRS								
15-12%	.034667 (3.73)[2]	.169214 (1.54)	-.00108 (-1.95)	-.00074 (-2.71)	-.000016 (-4.70)	-.000005 (-3.74)	.000891 (6.27)	.89
14-12%	.019375 (2.37)	.217765 (1.71)	-.000314 (-.66)	-.000618 (-2.53)	-.000008 (-2.93)	-.000005 (-3.77)	.000576 (4.64)	.88
13-12%	.009588 (1.65)	.173484 (1.32)	.000076 (.22)	-.000451 (-2.73)	-.000005 (-2.41)	-.000004 (-4.39)	.000418 (4.60)	.88
HRW	.0103318	.255971	.000046	-.000552	-.000005	-.000003	.000323	.83
13-ORD%	(1.55)	(1.75)	(.12)	(-2.91)	(-2.41)	(-2.69)	(3.42)	

[1] Derived using Hatanaka two-step estimator to estimate coefficients in a regression with serial correlation of lagged dependent variables.

[2] t-ratios in parentheses

TABLE A2. PRICE FLEXIBILITIES* FOR DIFFERENT PROTEIN LEVELS

Wheat	Short Run	Long Run	
HRS			
15-12%	- 9.68 - 5.54	-11.65 - 6.67	Own Cross
14-12%	- 4.82 - 7.89	- 6.16 -10.08	Own Cross
13-12%	2.05 -10.11	2.47 -12.22	Own Cross
HRW			
13-ORD%	- 7.46 .75	-10.33 1.01	Own Cross

*Derived using the reduced form equations and using mean values.

TABLE A3. PRICE ELASTICITIES* FOR PROTEIN

HRS		
15-12%	-.12 .09	Own Cross
13-12%	-.34 .10	Own Cross
HRW		
13-ORD%	-.23	Own
RESPECT TO 13-12	.28	Cross

*Derived from coefficients of derived structural demand model, using a static specification.

lower level protein premiums. In other words, changes in the supply of protein in HRW while impacting the entire market, have a greater impact on lower protein HRS wheat. This only suggests the greater substitutability of HRW with lower protein HRS. That impact diminishes but is still significant for higher protein premiums.

These results can be used to explain the relatively high protein premiums observed in recent years. Reductions in the past 3-4 years in both crop average protein levels, but especially that of HRW, have resulted in the increased protein premiums. Further, unless significant increases in protein levels develop, premiums at current levels will likely continue.

Appendix B

Protein Levels and Percent of Acres Planted to Each Variety

TABLE B1. STATE AVERAGE PROTEIN CONTENT BY VARIETY FOR KANSAS, 1974 TO 1986

1974		1975		1976		1977		1978		1979		1980	
Variety	Protein	Variety	Protein	Variety	Protein	Variety	Protein	Variety	Protein	Variety	Protein	Variety	Protein
Centurk	11.70	Scout	11.60	Scout	11.60	Scout	11.60	Eagle	11.87	Scout	11.60	Larned	11.67
Scout	11.60	Eagle	11.87	Eagle	11.87	Eagle	11.87	Scout	11.60	Eagle	11.87	Eagle	11.87
Santana	12.17	Centurk	11.70	Sage	11.85	Sage	11.85	Sage	11.85	Sage	11.85	Newton	11.83
Eagle	11.87	Parker	11.62	Triumph	11.87	Centurk	11.70	Centurk	11.70	Centurk	11.70	Scout	11.60
Bison	12.86	Gage	11.53	Centurk	11.70	Triumph	11.87	Triumph	11.87	Larned	11.67	Triumph	11.87
Parker	11.62	Triumph	11.87	Parker	11.62	Tam101	12.77	Tam101	12.77	Triumph	11.87	Sage	11.85
Gage	11.53	Chanute	11.50	Santana	12.17	Parker	11.62	Parker	11.62	Tam101	12.77	Centurk	11.70
				Gage	11.53	Santana	12.17	Larned	11.67	Buckskin	12.15		
				Tam101	12.77			Buckskin	12.15	Newton	11.83		
				Chanute	11.50					Gage	11.53		

1981		1982		1983		1984		1985		1986	
Variety	Protein	Variety	Protein	Variety	Protein	Variety	Protein	Variety	Protein	Variety	Protein
Newton	11.83	Newton	11.83	Newton	11.83	Newton	11.83	Newton	11.83	Newton	11.70
Eagle	11.87	Larned	11.67	Larned	11.67	Tam105	11.43	Tam105	11.43	Hawk	12.10
Scout	11.60	Eagle	11.87	Vona	11.10	Hawk	11.30	Larned	11.67	Arkan	12.10
Larned	11.67	Scout	11.60	Tam105	11.43	Larned	11.67	Hawk	11.30	Tam105	11.30
Triumph	11.87	Sage	11.85	Eagle	11.87	Vona	11.10	Vona	11.10	Larned	11.60
Vona	11.10	Vona	11.10	Scout	11.60	Eagle	11.87	Arkan	11.90	Mustang	11.80
		Tam105	11.43	Rocky	12.00	P1145	11.10	Scout/s66	11.60	Vona	12.50
						Rocky	12.00	Eagle	11.87	Eagle	12.40
						Scout	11.60			Scout/s66	11.90

SOURCE: Kansas Wheat Commission, Kansas Wheat Quality, various issues.

TABLE B2. EXPERIMENT STATION AVERAGE PROTEIN CONTENT BY VARIETY FOR NORTH DAKOTA, 1970 TO 1986

1970		1971		1972		1973		1974		1975		1978	
Variety	Protein	Variety	Protein	Variety	Protein	Variety	Protein	Variety	Protein	Variety	Protein	Variety	Protein
Chris	15.30	Bonanza	14.40	Bonanza	14.40	Bonanza	14.40	Bonanza	14.40	Chris	15.30	Butte	14.80
Justin	15.30	Chris	15.30	Chris	15.30	Bounty208	14.30	Bounty208	14.30	Ellar	15.40	Kitt	14.70
Manitou	14.80	Justin	15.30	Justin	15.30	Chris	15.30	Chris	15.30	Era	13.80	Olaf	14.90
Redriver	14.80	Manitou	14.80	Manitou	14.80	Era	13.80	Lark	14.40	Olaf	14.90	Prodax	14.40
Waldron	15.50	Polk	14.40	Polk	14.40	Justin	15.30	Olaf	14.90	Waldron	15.50	Waldron	15.50
ws1812	14.20	Waldron	15.50	Manitou	14.80	Manitou	14.80	Waldron	15.50			Wared	13.90
		ws1809	14.70	ws1809	14.70	Waldron	15.50	ws1809	14.70				
		ws1812	14.20			ws1809	14.70						

1979		1980		1982		1984		1985		1986	
Variety	Protein	Variety	Protein	Variety	Protein	Variety	Protein	Variety	Protein	Variety	Protein
Butte	14.80	Butte	14.80	Alex	15.30	Alex	15.30	Alex	15.30	Alex	15.30
Kitt	14.70	Coteau	15.90	Butte	14.80	Butte	14.80	Butte	14.80	Butte	14.80
Olaf	14.90	Kitt	14.70	Coteau	15.90	Coteau	15.90	Len	15.40	Coteau	15.90
Prodax	14.40	Len	15.40	Len	15.40	Len	15.40	Marshall	14.30	Guard	14.60
Solar	13.40	Olaf	14.90	Olaf	14.90	Marshall	14.30	pr2369	14.60	Len	15.40
Waldron	15.50	Prodax	14.40	Oslo	14.00	Oslo	14.00	Stoa	15.40	Leo747	14.75
Wared	13.90	Solar	13.40	Solar	13.40	pr2369	14.60	Waldron	15.50	Marshall	14.30
		Waldron	15.50	Waldron	15.50	Solar	13.40	Wheaton	14.30	Norak	14.20
		Wared	13.90	Walera	13.80	Waldron	15.50			pr2369	14.60
						Walera	13.80			Stoa	15.40
						Wheaton	14.30			Success	14.60
										Wheaton	14.30

SOURCE: North Dakota State University Agricultural Experiment Station, Department of Cereal Science and Food Technology, Analytical Milling and Baking Data, Field Plot Varieties, various issues.

TABLE B3. WHEAT ACRES PLANTED BY VARIETY IN KANSAS, 1974 TO 1986

1974		1975		1976		1977		1978		1979		1980	
Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted
Centurk	9.5	Scout	33.2	Scout	25.2	Scout	21.7	Eagle	23.0	Scout	15.6	Larned	11.1
Scout	36.5	Eagle	22.6	Eagle	20.1	Eagle	19.9	Scout	19.6	Eagle	21.1	Eagle	15.7
Santana	4.7	Centurk	9.8	Sage	10.1	Sage	14.7	Sage	14.0	Sage	12.7	Newton	17.5
Eagle	17.8	Parker	6.4	Triumph	7.9	Centurk	11.9	Centurk	10.0	Centurk	8.7	Scout	12.5
Bison	1.2	Gage	2.2	Centurk	9.8	Triumph	6.3	Triumph	5.8	Larned	8.4	Triumph	5.1
Parker	7.6	Triumph	8.2	Parker	5.0	Tam101	3.0	Tam101	4.1	Triumph	6.5	Sage	8.8
Gage	2.4	Chanute	2.0	Santana	3.5	Parker	3.0	Parker	1.7	Tam101	4.9	Centurk	5.9
Total	79.7	Total	84.4	Gage	2.4	Santana	2.9	Larned	2.8	Buckskin	2.2	Total	76.6
				Tam101	2.4	Total	83.4	Buckskin	2.7	Newton	2.8		
				Chanute	1.9			Total	83.7	Gage	1.2		
				Total	88.3					Total	84.1		

1981		1982		1983		1984		1985		1986	
Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted
Newton	34.2	Newton	41.1	Newton	38.5	Newton	30.9	Newton	25.7	Newton	21.1
Eagle	11.3	Larned	11.2	Larned	10.4	Tam105	13.1	Tam105	13.4	Hawk	13.5
Scout	9.2	Eagle	10.2	Vona	5.9	Hawk	9.0	Larned	8.6	Arkan	10.1
Larned	12.0	Scout	6.1	Tam105	10.3	Larned	10.2	Hawk	12.3	Tam105	6.8
Triumph	2.7	Sage	2.5	Eagle	6.0	Vona	5.7	Vona	4.4	Larned	7.9
Vona	6.7	Vona	5.5	Scout	4.8	Eagle	5.4	Arkan	6.3	Mustang	8.2
Total	76.1	Tam105	1.6	Rocky	2.2	pl145	2.4	Scout/s66	3.6	Vona	2.4
		Total	78.2	Total	78.1	Rocky	1.3	Eagle	4.0	Eagle	3.1
						Scout	4.2	Total	78.3	Scout/s66	2.6
						Total	82.2			Total	75.7

SOURCE: Kansas Experiment Station, Circular, various issues.

TABLE B4. WHEAT ACRES PLANTED BY VARIETY IN NORTH DAKOTA, 1970 TO 1986; 1976, 1977, 1981, and 1983 EXCLUDED

1970		1971		1972		1973		1974		1975		1978	
Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted
Chris	1.1	Bonanza	1.6	Bonanza	3.4	Bonanza	2.3	Bonanza	2.0	Chris	2.7	Butte	5.0
Justin	8.0	Chris	9.8	Chris	8.9	Bounty208	5.8	Bounty208	5.9	Ellar	2.2	Kitt	4.5
Manitou	24.1	Justin	3.9	Justin	3.1	Chris	5.9	Chris	4.1	Era	8.0	Olaf	0.5
Redriver	3.2	Manitou	8.2	Manitou	5.3	Era	2.6	Lark	8.6	Olaf	18.4	Prodax	3.3
Waldron	26.0	Polk	3.4	Polk	3.2	Justin	2.1	Olaf	4.2	Waldron	49.6	Waldron	28.3
ws1812	3.3	Waldron	62.0	Waldron	52.7	Manitou	2.1	Waldron	52.0	Total	80.9	Wared	2.3
Total	65.7	ws1809	1.8	ws1809	11.2	Waldron	53.8	ws1809	4.1			Total	43.9
		ws1812	1.1	Total	87.8	ws1809	9.1	Total	80.9				
		Total	91.8			Total	83.6						

1979		1980		1982		1984		1985		1986	
Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted	Variety	Percent Of Acres Planted
Butte	23.2	Butte	22.1	Alex	0.8	Alex	10.0	Alex	8.7	Alex	6.0
Kitt	2.1	Coteau	5.9	Butte	15.5	Butte	8.4	Butte	7.1	Butte	2.8
Olaf	39.2	Kitt	0.8	Coteau	11.9	Coteau	6.8	Len	18.5	Coteau	3.6
Prodax	5.1	Len	1.7	Len	27.6	Len	20.6	Marshall	30.1	Guard	0.4
Solar	2.0	Olaf	26.9	Olaf	14.7	Marshall	21.5	pr2369	4.7	Len	18.4
Waldron	22.7	Prodax	3.5	Oslo	0.5	Oslo	5.4	Stoa	3.5	Leo747	2.0
Wared	3.6	Solar	7.4	Solar	6.5	pr2369	1.1	Waldron	2.6	Marshall	13.5
Total	97.9	Waldron	18.5	Waldron	10.3	Solar	2.0	Wheaton	5.3	Norak	0.4
		Wared	2.1	Walera	2.2	Waldron	6.7	Total	80.5	pr2369	5.5
		Total	88.9	Total	90.0	Walera	3.0			Stoa	28.1
						Wheaton	0.5			Success	0.4
						Total	86.0			Wheaton	4.0
										Total	85.1

SOURCE: North Dakota State Wheat Commission, North Dakota Wheat Varieties, various issues.

Appendix C

A Production Characteristic Function For Wheat Yields and Protein

This appendix develops the profit maximizing conditions for a yield-quality trade-off.

The production-characteristic function is

$$y = f(F,\rho)$$

where y is yield per acre, F is fertilizer input, and ρ is protein.

Also, $\frac{\partial f}{\partial F} > 0$, $\frac{\partial^2 f}{\partial F^2} < 0$, $\frac{\partial f}{\partial \rho} < 0$, $\frac{\partial^2 f}{\partial \rho^2} < 0$, and $\frac{\partial^2 f}{\partial F \partial \rho} > 0$

The price-characteristic function is

$$P(\rho) = P_0 + a(\rho - \rho_0)$$

where ρ_0 is a base level protein and P_0 the price for a corresponding quality of output.

The profit function is

$$\pi = P(\rho)y(F\rho)-P_F F$$

where ρ_F is the fertilizer price. The first order conditions for maximization are

$$\frac{\partial \pi}{\partial F} = P(\rho)\frac{\partial y}{\partial F} - P_F = 0, \text{ and } \frac{\partial \pi}{\partial \rho} = P(\rho)\frac{\partial y}{\partial \rho} + \frac{\partial P}{\partial \rho}y = 0$$

$$\text{Thus, } f_F(F,\rho) = \frac{P_F}{P(\rho)} \text{ and } -\frac{f_\rho(F\rho)}{f(F,\rho)} = \frac{\partial P}{\partial \rho}/P(\rho) = g$$

The first order conditions suggest that producers adjust protein and fertilizer decisions when relative fertilizer product prices and percentage protein premiums vary. Thus, econometric analysis of protein response can be conducted with two explanatory variables: g and $\rho f/\rho$.

The percentage yield loss function is

$$l(F,\rho) = \frac{-f_\rho(F,\rho)}{f(F,\rho)} \quad \text{So, } \Delta l(F,\rho) = \frac{\partial l}{\partial F}\Delta F + \frac{\partial l}{\partial \rho}\Delta\rho$$

where,

$$l_\rho = \frac{\partial l}{\partial \rho} = \left(\frac{f_\rho}{f}\right)^2 - \frac{f_{\rho\rho}}{f} > 0 \text{ and } l_F = \frac{\partial l}{\partial F} = \frac{f_\rho f_F}{f^2} - \frac{f_\rho f}{f} < 0$$

Given the price function, $\frac{\partial P}{\partial \rho}/P = g = \frac{a'(\rho)}{P_0 + a(\rho)}$

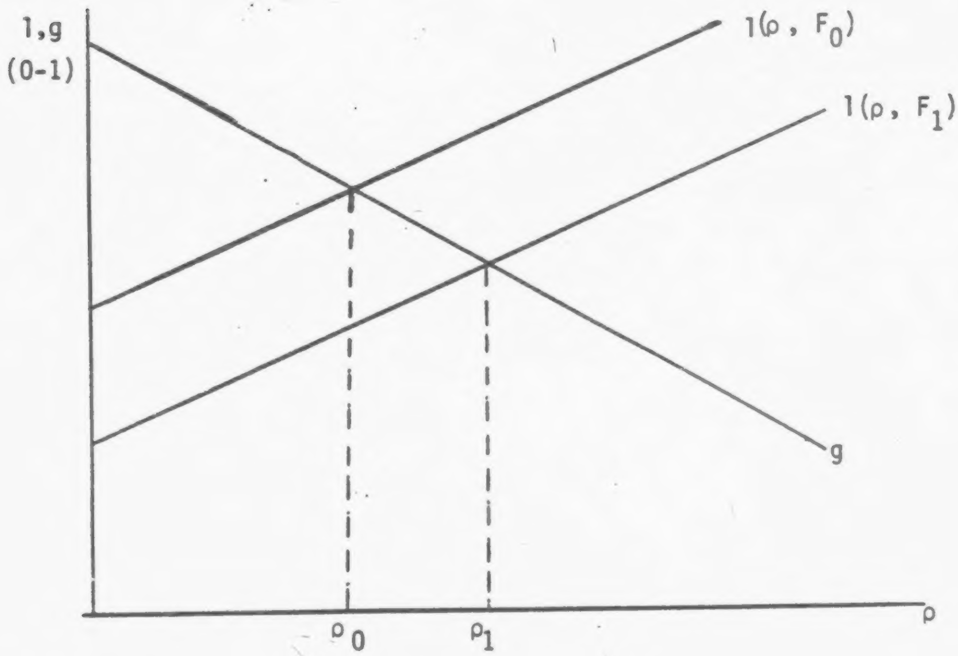
So the effects of separate price level and premium changes are

$$\frac{\partial g}{\partial P_0} = \frac{-[a'(\rho)]^2}{[P_0 + a(\rho)]^2} < 0 \text{ and } \frac{\partial g}{\partial \rho} = \frac{[P_0 + a(\rho)]a''(\rho) - [a'(\rho)]^2}{[P_0 + a(\rho)]^2}$$

$$\text{So } \frac{\partial g}{\partial \rho} < 0 \text{ if } \frac{a''(\rho)}{a'(\rho)} < \frac{1}{P(\rho)}$$

This condition states that the percentage price premium schedule will decline with protein increases unless the slope increases very rapidly (the second derivative is very large). The slope will usually decrease.

The protein choice decision may be illustrated graphically as follows. The decision rule above says that producers increase protein until the percentage yield loss from increasing protein equals the percentage price gain. Below, "g" indicates the percentage price gain, which is downward sloping for the price-quality function assumed here. The yield-loss curve is upward sloping. The equilibrium protein level occurs when the g and l curves intersect. Also, it was shown that $l_F < 0$, so an increase in fertilizer use will shift the percent yield schedule downwards.



Appendix D

Yield Response Analyses

This appendix contains estimates of wheat yield response for Kansas and North Dakota. The underlying theory and estimation to price approach is summarized by Gallagher (1986). The results of these estimations are given below

Kansas

$$YK_t = \underset{(7.3)}{95.57} + \underset{(3.6)}{5.745}\,\frac{PK_t}{PF_t}\,SK_t - \underset{(-1.9)}{.001066}AK_t - \underset{(4.7)}{0.9836}TK_t$$

$\bar{R}^2 = .72$ D.W. = 1.6 $\bar{s} = 9.5$

Variable Definitions

YK_t = Kansas yield per harvested acre, bu/acre
PK_t = Kansas season average farm price + deficiency payment
PF_t = price of nitrogen fertilizer, in $/ton
SK_t = percent of area planted with semi-dwarf hybrids (0-100)
AK_t = area planted to wheat in Kansas, thousand acres
TK_t = average April temperature in Kansas (°F) .

Historical period 1967-1986

North Dakota

$$YN_t = \underset{(4.6)}{137.12} + \underset{(3.3)}{5.433}\,\frac{PN_t}{PF_t}\,SN_t - \underset{(1.8)}{.0015}AN_t - \underset{(3.7)}{1.573}TN_t + \underset{(1.0)}{0.4526}R_t$$

$\bar{R}^2 = .57$ D.W. = 1.63 $\bar{s} = 10.5$

YN_t = North Dakota yield per harvested ared, bu/acre
PN_t = North Dakota season average farm price + deficiency payment, $/bu
PF_t = price of nitrogen fertilizer, in $/ton
SN_t = percent of area planted with semi-dwarf hybrids, percent (0-100)
AN_t = area planted to wheat in North Dakota, thousand acres
TN_t = July temperature in North Dakota, (°F)
R_t = season average rainfall, in inches

Historical period 1967-1986

The data used for these estimations is given in Table D1.

These yield response functions were used in the assessment of potential protein adjustment. To do this, 1986 economic conditions and historical averages of weather variables were used to obtain a linear approximation to the yield response function.

For Kansas, the appropriate values of independent variables are

$PK_{86} = 2.20 + 1.98 = 4.18$
$PF_{86} = 175$
$SK_{86} = 68.9$
$A_{86} = 11,500$
$T_{86} = 54.98$

The linear approximation of the relation between yield and price is

$$Y_K = 29.233 + 2.2619P_K$$

At current prices the "normal" weather yield estimate is $\hat{y}_K = 38.7$

For North Dakota, independent variable values are

$PN_{86} = 2.45 + 1.98 = 4.43$
$PF = 175$
$SN_{86} = 70.7$
$AN_{86} = 6500$
$\bar{F} = 7.87$
$TN_t = 69.4$

The linear yield estimate is $Y_N = 21.76 + 2.195PN_t$, and the normal weather yield estimate with 1986 prices is $\hat{Y}_N = 31.38$.

Yield loss coefficients for the profitability analysis were computed with the following procedure. First, percentage yield losses were calculated at base levels with experiment station trade-off estimates. The yield loss for North Dakota was calculated at 14 percent protein as follows

$$\frac{b}{y_0} = \frac{2.7}{89.47 - 2.70(14)} = .0523$$

For Kansas, the semi-dwarf trade-off was used and the base protein level was taken at 11 percent

$$\frac{b}{y_0} = \frac{3.269}{95.481-3.269(11)} = \frac{3.269}{59.52} = .055$$

Then these percentages were applied to state average yields. For North Dakota

$$b_N = 0.523 \cdot \hat{Y}_N = 1.64$$

For Kansas, $b_K = .055 \cdot \hat{Y}_K = 2.13$

APPENDIX TABLE D1.

Year	ND July Temp.	Kansas April Temp.	ND Yield Per Harvested Acre	Kansas Yield Per Harvested Acre	Wheat Acres Planted to Semi-Dwarf Varieties		Kansas Wheat Acres Planted To Varieties Released Post-1965
					ND	Kansas	
			----- bu/acre -----		-------------- percent ------------------		
1967	68.5	58.3	22.0	20.0	0.0	0.0	23.1
1968	67.8	54.5	26.0	26.0	0.0	0.1	40.8
1969	67.6	56.1	28.5	31.0	1.6	2.5	52.2
1970	71.3	53.6	23.0	33.0	6.5	7.7	63.4
1971	65.3	55.5	31.5	34.5	6.0	18.3	71.5
1972	65.2	55.5	29.0	33.5	14.6	24.2	78.7
1973	68.2	51.3	27.5	37.0	28.8	18.3	82.3
1974	73.0	56.4	20.5	27.5	31.7	16.7	85.1
1975	72.2	53.6	25.5	29.0	30.9	13.1	86.0
1976	70.0	56.6	24.5	30.0	39.0	14.8	70.8
1977	70.0	58.1	25.0	28.5	43.0	11.8	65.7
1978	68.4	56.8	29.0	30.0	50.0	10.7	61.6
1979	70.0	53.5	26.5	38.0	44.0	13.7	51.8
1980	70.8	52.9	18.5	35.0	46.1	30.0	38.5
1981	70.0	62.1	28.0	25.0	50.0	48.1	25.3
1982	69.5	52.0	31.0	35.0	57.5	54.3	19.9
1983	72.6	47.4	27.0	41.5	57.4	53.4	13.8
1984	70.1	49.5	34.0	39.0	61.5	53.9	11.5
1985	69.0	58.0	36.0	38.0	69.4	68.9	8.9
1986	68.6	58.0	31.0	33.0	70.7	68.9	7.0

- CONTINUED -

APPENDIX TABLE D1. (CONTINUED)

Year	Fertilizer Price	Kansas Season Average Price	ND Season Average Price	Deficiency Payments	ND Cumulative Season Precipitation	Kansas Wheat Planted Acres	ND Wheat Planted Acres
	--$/ton-+-	----------	¢/bu	--------------	----inches---	-thousand	acres-
1967	74	135	144	48	4.360	13,146	5,788
1968	68	122	133	55	8.740	11,963	5,076
1969	62	119	139	64	9.150	10,767	4,090
1970	60	125	148	75	9.260	9,690	4,830
1971	63	132	130	54	9.070	9,593	6,762
1972	65	168	188	47	8.000	10,300	5,221
1973	71	375	428	22	6.030	10,800	6,270
1974	139	386	445	0	7.559	12,000	6,770
1975	186	342	405	0	9.360	12,800	6,400
1976	135	259	267	0	5.220	12,900	8,080
1977	141	224	240	65	9.340	13,200	7,200
1978	140	289	280	52	9.270	11,300	6,300
1979	138	372	353	0	8.900	12,100	6,400
1980	165	378	392	0	5.600	13,000	7,200
1981	185	376	359	15	8.540	13,900	7,200
1982	195	356	371	50	9.040	14,100	7,000
1983	185	350	369	65	7.530	13,200	5,100
1984	198	335	350	115	5.560	13,300	5,450
1985	192	301	334	108	7.200	12,700	5,850
1986	175	220	245	198	9.610	11,500	6,500

APPENDIX TABLE D2. DATA FOR PROTEIN RESPONSE ANALYSIS

Year	TN_t	gn_t	gk_t	SN_t	OVK_t	SK_t	PN_t	PK_t	TK_t
1971	65.3	0.0340	0.021	6.0	71.5	18.3	13.5	12.1	55.5
1972	65.2	0.0126	0.009	14.6	78.7	24.2	14.0	11.7	55.5
1973	68.2	0.0091	0.009	28.8	82.3	18.3	14.6	11.1	51.3
1974	73.0	0.0532	0.045	31.7	85.1	16.7	15.2	11.4	56.4
1975	72.2	0.0881	0.041	30.9	86.0	13.1	14.1	11.4	53.6
1976	70.0	0.0385	0.048	39.0	70.8	14.8	14.3	11.7	56.6
1977	70.0	0.0229	0.017	43.0	65.7	11.8	14.5	12.5	58.1
1978	68.4	0.0111	0.003	50.0	61.6	10.7	13.6	12.0	56.8
1979	70.0	0.0127	0.008	44.0	51.8	13.7	13.7	12.1	53.5
1980	70.8	0.0371	0.003	46.1	38.5	30.0	14.7	12.3	52.9
1981	70.0	0.0110	0.002	50.0	25.3	48.1	14.2	13.2	62.1
1982	69.5	0.0150	0.026	57.5	19.9	54.3	14.0	11.4	52.0
1983	72.6	0.0161	0.044	57.4	13.8	53.4	14.4	11.3	47.4
1984	70.1	0.0470	0.030	61.5	11.5	53.9	14.1	11.6	49.5
1985	69.0	0.0883	0.046	69.4	8.9	57.2	13.8	11.6	58.0
1986	68.6	0.1045	0.035	70.7	7.0	68.9	14.2	11.9	58.0

Variable Definitions:

TN_t = July temperature in North Dakota

gn_t = percentage increase in price from a one percent increase in protein content Minneapolis market, in percent (0-1)

gk_t = percentage increase in price from a one percent increase in protein content, Kansas City market, in percent (0-1)

SN_t = percent of area planted to semi-dwarf varieties in North Dakota (0-100)

OVK_t= percent of area planted to varieties released after 1965 that are not semi-dwarf varieties

Sk_t = percent of area planted to semi-dwarf varieties in Kansas City (0-100)

PN_t = state average protein content in North Dakota, in percent (0-100)

PK_t = state average protein content in Kansas, in percent (0-100)

TK_t = April temperature in Kansas

Appendix E

Preliminary Regressions With State Average Protein Content

Preliminary regressions used the average protein content of Kansas and North Dakota wheat crops as the explanatory variable. These regressions were similar for both states. The results indicated that in neither series was there evidence of a response to protein premiums. Also, variation in both state's protein level is explained by the average temperature during the month prior to harvest. Finally, there is a slight downward trend in average protein levels for both states. This trend coincides with and may be attributable to the adoption of semi-dwarf and other seed varieties, which on average have lower protein levels than the technology which was available at the beginning of the sample period.

To analyze these relationships further, the models were respecified to include critical weather variables and the percent of area planted to semi-dwarf varieties. In the case of North Dakota the following regression was estimated:

$$\begin{array}{llllll} \rho = & 4.700 & - .006718 \cdot S & + & .1405 & \text{July temp} \\ & (1.5) & (1.2) & & (3.0) & \end{array}$$

$$\bar{R}^2 = .32 \qquad \text{D.W.} = 1.98 \qquad \bar{s} = .36$$

where S is the percent of area planted to semi-dwarfs and July temp is the mean temperature in July in North Dakota. The results illustrate the important positive influence of July temperature on protein and suggest that increased semi-dwarf planting has resulted in lower state average protein levels, although the coefficient for the latter variable is insignificant.

The estimates for Kansas are similar, except that two generations of technology are identified. The regression below includes April temperature, (April temp) the percent of area planted to semi-dwarf varieties and the percent of area planted to varieties introduced after 1965 which are not semi-dwarf seeds (OV) the estimated regression is:

$$\underset{(5.5)}{\rho = 8.294} - \underset{(2.7)}{.02053\ OV_t} - \underset{(2.5)}{0.02717\ S_t} + \underset{(4.0)}{.09845} \text{ April temp}$$

$\bar{R}^2 = .56$ D.W. = 1.75 $\bar{s} = .35$

t-ratios are in parenthesis.

The results again, illustrate the importance of temperature on protein, in this case, the April temperature. However, the impacts of breeding programs as reflected in the percentage of area planted to semi-dwarf varieties has resulted in reduced state average protein levels.

Background Paper No. 3

Effect of Domestic Regulatory Policies on U.S. Grain Technology and Quality

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THE EFFECT OF DOMESTIC REGULATORY POLICIES ON U.S. GRAIN TECHNOLOGY AND QUALITY

1. Introduction

The Federal Interest in Grain Quality:

As the value and quantity of U.S. grain exports have declined since the highs of the late 1970s and early 1980s, and as foreign competitors have captured grain export markets previously served by the United States, federal policymakers have paid increasing attention to the fundamental issue of U.S. grain quality.

Increased governmental attention has tended to be at the behest of the Congress in the exercise of its oversight of the Federal Grain Inspection Service (FGIS), an agency within the U.S. Department of Agriculture (USDA). FGIS' mission is the establishment of official United States Standards for Grain, their uniform application and implementation in the public interest.

A decade of consideration of U.S. grain quality was inaugurated by the October 21, 1978 FGIS Report to Congress on the Adequacy of U.S. Grain Standards, as mandated by section 24 of Public Law 94-582, October 21, 1976, 90 Stat. 2867, 7 U.S.C. 87f, 2 Note (1976). This was followed by the November 30, 1979 report by the General Accounting Office (GAO), Federal Export Grain Inspection and Weighing Programs: Improvements Can Make Them More Effective and Less Costly [CED-80-15].

The Interest in Quality Quickens:

With U.S. grain exports peaking during consideration of federal farm legislation in 1981, attention to fundamental grain quality issues languished. However, after grain exports declined during the first half of the decade, interest in the issue revived with the Food Security Act of 1985's [Public Law No. 99-198, December 23, 1985, Title XVI, sec. 1671, 99 Stat. 1632 (1985)] directive that the Office of Technology Assessment (OTA) conduct a study of U.S. grain export quality standards and grain handling practices. The OTA study, for which this article was prepared as background information, is scheduled to be released in the Summer of 1988.

As conditions continued to worsen in the U.S. farm economy despite the passage of the 1985 Farm Bill, Congress continued to direct attention to the quality issue in Congressional debates leading to passage of the Grain Quality Improvement Act of 1986 [Public Law 99-641, Title III, Sec. 301 et seq., 100 Stat. 3564 (1986), amending 7 U.S.C. Chapter III].

As U.S. agricultural trade slipped into a net deficit position in May of 1986 for the first time in 15 years, complaints about the quality of U.S. grain exports were also accelerating. [Remarks of Hon. Charles Grassley, Congressional Record, October 17, 1986, p. S15275]. Legislative concern on the subject continued to increase with the May 19, 1986 publication of the General Accounting Office Report, U.S. Grain Exports: Concerns About Quality [GAO/RCED-86-134].

The U.S. Quality Problem:

Just how good is U.S. grain in comparison to other net exporters'? Why have foreign complaints about U.S. grain been rising in recent years? Why have many foreign buyers evinced an interest in Canadian and Australian wheat over U.S. wheat, if not a preference for it?

The answers to these questions are as complex as the issues of responsibility for poor U.S. grain quality and declining U.S. exports are controversial. In view of the crash of U.S. agricultural exports from their peak of $44 billion at the outset of the Reagan era in 1981 to last year's level of $26 billion, farmers and the grain-handling industry often have tended to point fingers toward government regulatory policies as one of the contributing factors for the U.S. decline, in addition to commodity price support program policies.

At the same time, progressive individuals involved with the U.S. grain trade at times will privately admit that U.S. grain is not as good in quality, that complaints have been rising in view of the U.S. practice of often blending dust and other non-grain materials back in with the grain prior to shipment, and that, for example, Canadian or Australian wheat is simply much cleaner. To be fair, surveys taken as part of the GAO and FGIS studies cited above clearly show that not every U.S. export elevator engages in such blending practices; however, a significant enough percentage of such elevators do so blend their grain to result in an undermining of the U.S. reputation for reliable grain quality control.

The reason for the U.S./foreign difference in quality control perhaps stems from a pervasive philosophical difference in belief systems: whereas the Canadian or Australian believes he is in the business of selling grain and that the onus is on him to provide a cleaner and better product at every step of the way, the

U.S. grain merchant often believes that he in in the business of selling what he receives.

Accordingly, instead of taking dust, weed seeds, garlic bulbs, silica, insects and fragments out of the grain as a matter of course at every step of the process, the U.S. grain merchant may often remove dust, weed seeds, sand, etc., for air quality or safety reasons at one step of the process, only to blend all of what many would call the "trash" back in at a later stage of the process. This practice produces the "lowest common denominator" grain meeting minimal USDA standards or contractual specifications.

Needless to say, if it is as widespread as congressional proceedings on the subject of grain quality seem to indicate, this "do the minimum" approach is not conducive to developing a reputation for quality in world markets. Congressional debates over the Grain Quality Improvement Act of 1986 actually implied that the situation is much worse, with U.S. grain handlers even adding dirt, glass, and other foreign material to lower blended grains to the minimum quality limits allowed under federal grading standards. [E.g., Remarks of Hon. Tom Harkin, Congressional Record, October 17, 1986, p. 15281].

A Point of View and Explanation

It is not the purpose of this paper to investigate or substantiate all of the charges which have been made in legislative proceedings, GAO reports, or foreign or domestic consumers' complaints about grain quality. Nor is it the purpose of this paper to offend members of the U.S. grain industry or to denigrate or deny the efforts of those in the U.S. grain industry who are genuinely working for improved U.S. grain quality. These efforts should be applauded and encouraged. The purpose of this paper is not to provide a fact-finding or investigative report documenting the charges which have been made before Congress or GAO over the last decade about poor U.S. grain quality.

On the contrary, this paper is a regulatory policy paper. It **assumes** that there is, in fact, a serious U.S. grain quality problem; likewise, it **assumes** that the charges and allegations which have been made before Congress and GAO about U.S. grain quality and U.S. grain-handling practices are essentially correct. The paper then explores how the implementation of various U.S. regulatory policies in the area of environmental protection, public health, and occupational safety might impact or promote the public interest in improving U.S. grain quality.

By making these assumptions, this paper in essence adopts the grain consumer's point of view and examines how the implementation of regulatory policies might promote the consumer's interest in better quality grain.

The author realizes that many in the grain-handling industry vigorously dispute the allegations which have been made before Congress and GAO over the last decade about poor U.S. grain quality. These readers may not feel that a paper which (1) assumes that the allegations about poor quality are correct and (2) adopts the consumer's point of view is a fair or balanced presentation of the issue. The author apologizes to these readers and means to give them no offense.

However, again taking the consumer's point of view, the author submits that the burden of proof is on the grain-handling industry to either show that no grain quality problems as alleged exist or to demonstrate improvements made in industry practices to promote grain quality. In the interest of debate and discussion, the author suggests that readers from the grain-handling industry try to adopt the consumer's point of view as they read this paper. The more that grain-handling and distribution practices are tested in the crucible of consumer demands and expectations, the more likely it is that U.S. grain quality will improve.

The Role of Regulatory Policy:

Allegations or suggestions that domestic U.S. regulatory policies have played a key role in declining U.S. performances in international markets--resulting in poorer grain quality and lower exports--are serious ones worthy of critical examination. Indeed, have domestic regulatory policies had adverse effects on U.S. grain technology and quality? Or have domestic regulatory policies tended to promote grain quality objectives? If the answer to both of these questions is yes, then are domestic regulatory policies consistent and coherent? Can they be implemented in an intelligent, coordinated manner to eliminate adverse effects on quality and to enhance the wholesomeness of U.S. grain delivered to the international marketplace?

Organization of Discussion

This article examines the diverse, overlapping, and at times competing, domestic regulatory policies which have an impact upon U.S. grain technology and quality. Whether the regulatory objective is (1) to preserve the integrity of the grain-handling, storage and delivery system to protect the consumer, (2) to protect the public health, (3) to serve the goal of environmental protection, or (4) to ensure the occupational safety of grain industry workers, domestic regulatory policies have a definite impact upon U.S. grain technology and quality.

Domestic regulations serving each of these objectives, their respective statutory authorities and agencies entrusted with their implementation, will be scrutinized below to discern their impact, pro or con, on U.S. grain quality. At the conclusion of the analysis, if public policy options to improve grain quality through better regulatory implementation, interpretation, or remedial legislation are in order, they will be suggested.

2. Grain Standards:

Consumer Protection or Trade Facilitation?

FGIS: Implementing United States Grain Standards

Any examination of the effect of domestic regulatory policy on U.S. grain quality must begin with the official United States Grain Standards, promulgated pursuant to the United States Grain Standards Act of August 11, 1916, as amended [Chapter 313, Part B. Sec. 1, 39 Stat. 482; as amended August 15, 1968, Public Law No. 90-487, 82 Stat 761; as amended October 21, 1976, Public Law 94-582, 90 Stat. 2867; as amended November 10, 1986, Public Law 99-641, Title III, sec. 301, 100 Stat. 3564], and the regulations of the Federal Grain Inspection Service implementing that Act.

The first U.S. grain standards were adopted for corn on December 1, 1916. Since that time, standards have been adopted for wheat, oats, rye, sorghum, barley, flaxseed, mixed grain, soybeans, triticale, and sunflower seed [USDA/FGIS, Historical Compilation of Changes in the Grain Standards of the United States, July 1986].

The Consumer Protection Interest: Since their inception, United States Grain Standards have served the twin purposes of consumer protection and trade facilitation. With regard to consumer protection, a panoply of quality factors are addressed in the various grain standards which protect the buyer and consumer of grain. These include odor, broken or damaged kernels, foreign material, the presence of stones, glass, castor beans, cockleburs, rodent or animal filth, color, amount of moisture, whether weevily or not, and the presence of garlicky, stained, mottled, heat damaged, smutty, musty, sour, ergoty or tough grain [Official U.S. Standards for Grain are codified at 7 CFR Chapter VIII; with wheat at 7 CFR 810.301 - 810.309, corn at 7 CFR 810.351 - 810.353, and soybeans at 7 CFR 810.601 - 810.609].

The authorizing statute for the standards, through its emphasis on proper weights and measures and the consideration of the public health, safety, or interest by the FGIS Administrator [See, e.g. 7 U.S.C. 76, as amended], makes it clear that consumer protection to ensure the integrity of the grain marketing system is one of two federal regulatory interests being served.

Trade Facilitation: In dynamic tension, if not conflict, to this objective is the discretion the statute gives the FGIS Administrator to fix and establish grain standards "as in his judgment the usages of the trade may warrant and permit", as well as his discretion "to amend or revoke such standards or procedures whenever the necessities of the trade may require." [7 U.S.C. 76]. It is clear then, also that the FGIS Administrator is required to look to the grain trade and, in a sense, take into account the usages and necessities of the trade when promulgating standards. As such, the grain standards should seek to facilitate and promote trade, while also serving their consumer protection objectives. In this regard, United States Grain Standards serve as reference points, or even as "supplemental trading rules" to promote the orderly conduct of grain transactions. Indeed, many of the provisions of the original grain standards adopted earlier in this century essentially tracked established trading practices for the commodities.

The Conflict: Public Interest or Private Preserve?

The dynamic tension and conflict between regulatory objectives comes when FGIS is presented with a proposal to further its responsibility to protect the consumer of grain, with a potential cost to the grain-handling industry. FGIS has a difficult time walking the line inherent in the language of its organic statute, discussed above, balancing its pro-active role to change trade practices for consumer protection and public interest, while taking into account the "usages" and "necessities" of the grain trade.

It has been charged by important grain-consuming interests that the U.S. grain trade often seems to treat

FGIS as its private preserve, taking a dim view of any initiative originating within FGIS in the pursuit of its consumer and other public interest functions. FGIS reinforces this impression when timely and meritorious proposals or complaints on grain quality matters, such as insect infestation or blending practices, are simply tabled or dropped in the name of avoiding the disruption of orderly grain markets [See, e.g., Hearings Before the Subcommittee on Rural Development Oversight and Investigations, Senate Committee on Agriculture, Nutrition and Forestry, Testimony of Donald Mennel, April 24, 1986].

The System for Grain Quality Complaints: Grain quality complaints may originate with foreign customers of U.S. grain or with domestic U.S. processing industries. While there is a formal FGIS complaint system for foreign buyers of U.S. grain through USDA's network of agricultural attaches around the world, it is little more than an information-gathering tool. Customer satisfaction or results under the complaint system are wholly dependent on the exercise of the FGIS Administrator's discretion, or the exercise of political influence on Capitol Hill by foreign governments. The Act requires the Administrator to report foreign complaints on U.S. grain quality to the respective Agriculture Committees of the House and Senate [7 U.S.C.

87e(b), 87f-2(b), (c)].

However, GAO has reported that although the number of complaints received by USDA from foreign buyers has been increasing in recent years, official complaints do not reflect the whole situation. Foreign purchasers simply do not use the official system in view of their experience that FGIS can do little or nothing to help them resolve their disputes with U.S. exporters. This is an impression which FGIS officials themselves may sometimes reinforce explicitly or through inaction.

Given (1) the broad rulemaking and investigative authorities provided the FGIS Administrator [7 U.S.C. 87e], as well as (2) broad enforcement, subpena, and other powers granted the FGIS Administrator to effectuate the purposes of the United States Grain Standards Act [7 U.S.C. 87f], it is obvious that, as a legal matter, FGIS could do a lot to resolve such disputes in the interest of promoting grain quality. However, FGIS, in the exercise of its wide discretion under the statute, has chosen not to utilize fully the broad powers granted to it.

Domestic processing industries with complaints about grain quality have even less of a chance at FGIS. Apart from political action on Capitol Hill incident to oversight, there is no formal, legal process which guarantees that a meritorious complaint about grain quality or proposal to improve grain quality will be heard with an opportunity for all interested views to be expressed and a balanced decision made. Again, despite broad rulemaking powers under the statute [7 U.S.C. 87e], such powers have not been used to promote access and transparency in proceedings to deal with domestic customer complaints.

However, FGIS, in the exercise of its discretion under the Act, cannot and should not be faulted for poor administrative practice in not fully utilizing its rulemaking authorities in view of (1) the dual purposes of the grain standards, discussed above, (2) the origin of the first standards in private grain trading rules, and (3) the unlimited discretion (but for Congressional oversight) of the FGIS Administrator to consider "trade usages and necessities" in making decisions.

Accordingly, if the claims of foreign and domestic grain consumers are correct that FGIS's implementation of United States Grain Standards is biased towards sellers in the grain-handling industry, there is a good legal basis for the bias: Within the scope of the law as presently written, it is FGIS' prerogative to look to the grain trade and favor its interpretations.

Administrative Options for Change: At the same time, within the same legal authority cited above, FGIS can be administered with its priorities weighted towards its consumer protection objectives and the improvement of grain quality. Another alternative, also possible under present law, is a balanced, neutral administration of FGIS. Procedural safeguards could be used more fully and adopted by regulation under existing authorities to ensure that customers' complaints and proposals to change the grain standards are heard in a public forum, with opportunities for all sides to be heard on the public record. Instead of what consumer interests may feel are secret decisions made for the few and the powerful in the trade, open decisions would be made in a public forum, balancing the goals of consumer protection and trade facilitation.

Reform: Grain Quality Improvement Act of 1986

A New Emphasis on the Consumer: A decade of discussion and complaint about U.S. grain quality on Capitol Hill has begun to pay off for the consumer. Some of the first legislative steps have now been taken to improve FGIS's functions in pursuit of its consumer protection and public interest objectives.

The Grain Quality Improvement Act of 1986 [Public Law No. 99-641, 100 Stat. 3564, 7 U.S.C. 71 note] makes it explicit U.S. policy (1) to promote the marketing of high quality grain, (2) to ensure that the primary objective of the Official United States Grain Standards is to accurately determine grain quality; and (3) to provide a framework to establish grain quality improvement standards.

Requirements were also established by the Act to address specific, recurring buyer complaints about U.S. grain quality regarding blending practices, foreign material recombination, dockage, rounding rules, and insect infestation. Each of the required actions revising FGIS' regulatory regime is discussed in the subsections which follow.

In addition, due to the recurring complaint of insect infestation of U.S. grain, the Act required the FGIS Administrator to issue a final rule revising grain inspection procedures and standards established under the United States Grain Standards Act [7 U.S.C. 71 et seq.] to more accurately reflect levels of insect infestation.

Mandated Studies for Future Action:

Premium and Discount Schedules. Furthermore, it should be noted that the Act mandated a number of studies to serve the interests of consumers and buyers of U.S. grain and the public interest in a reputation for quality grain exports. USDA [7 U.S.C. 76 note] was required to study the modification of grain premium and discount schedules to encourage the delivery, storage and export of high quality grain.

USDA/CCC released its report in response to this request in May 1987. While generally finding that CCC premium and discount schedules should reflect trade practices and market conditions, USDA/CCC stated: "A general program to clean all grain delivered from the farm should be considered. Studies submitted indicate that grain cleaning is practiced by certain firms and by some of our foreign competition. Firms report that the cleaning of grain costs about 3 1/2 cents per bushel. This practice would improve the overall quality of U.S. grain. Most of the cost of cleaning the grain would be recovered by improved storability and quality. The dumping of cleanings or other foreign material back into the cleaned grain would have to be banned in order to achieve the desired results" [USDA/CCC Study of Premiums and Discounts to Improve Grain Quality, May 1987].

End-Use Values & Optimal Grain Grading. FGIS was mandated [7 U.S.C. 76 note] to conduct studies of the need for and availability of uniform end-use value tests for grain, "including a survey of domestic and foreign buyers of grain to identify the information about grain characteristics **that would be most useful to such buyers.**" [Emphasis added].

FGIS was also mandated by the Act [7 U.S.C. 76 note] to conduct a study of additional legislative proposals to improve grain quality which had been embodied in the Optimal Grain Grading Act of 1986, a measure proposed, but not passed, during the 99th Congress as H.R. 5354. Included in this latter study, FGIS was directed to consider the general objective of improving grain quality by revising the official United States Grain Standards "to provide greater economic incentives for the production and sale of high-quality grain."

A First Step, But Is It Enough? If FGIS had the reputation of being biased toward sellers and grain merchants, the legislative changes discussed above will now swing the pendulum back towards a more even balancing of interests. However, in the specific areas addressed by the Grain Quality Improvement Act, much remains to be done. Some in the grain-handling industry were successful in modifying its provisions as discussed below.

Foreign Material Recombination: The most important amendment to the United States Grain Standards Act made by the Grain Quality Act of 1986 was the expansion of prohibited acts [7 U.S.C. 87b] to provide, with certain limitations, that "(A) no dockage or foreign material, as defined by the Secretary, once removed from grain shall be recombined with any grain; and (B) no dockage or foreign material of any origin may be added to any grain."

Blending Practices: However, the basic prohibitions against adding foreign material and dockage are followed by six different exceptions which weaken them. In particular, the exception which allows "the blending of grain with a similar grain of a different quality to adjust the quality of the resulting mixture" [7 U.S.C. 87b (d)(1)(C)], has the effect of placing a statutory imprimatur on current grain trade blending practices. As such, this exception, as a legal and practical matter, vitiates the effect of the prohibitions against the addition of dockage and foreign material. Indeed, if dirty wheat can still be blended with clean wheat to produce "seemingly clean" wheat to meet minimal grain grade standards or contractual specifications, the prohibition will not have achieved its desired effect.

U.S. blending practices have been the subject of numerous foreign complaints, with key export markets, such as Japan, [GAO reports, cited above] being particularly vocal in complaining against the U.S. practice of blending lower qualities with higher qualities of grain to meet minimum requirements. The Soviet Union, a market of which the U.S. has been trying to regain a greater share since the 1980 U.S. agricultural export embargo, has expressed similar concerns about U.S. grain quality.

GAO has investigated and reinvestigated this subject [See GAO references cited on pages 1-3 of the text, supra]. GAO has made detailed recommendations that FGIS conduct research on the need to restrict or prohibit certain blending practices, such as the practice of adding low-quality grain or different types of grain to good quality grain, or blending wheat with known sprout damage with wheat that does not contain such damage, or the blending of high-moisture corn with low-moisture corn.

A Fuller Disclosure on the Certificate: Another recommendation which has been made over the course of the last decade of GAO and Congressional consideration of this issue is that the U.S. Grain Standards Act be amended to require that the crop year and grain variety be stated on official grain inspection certificates. Currently, it is unlawful to so state, which protects the grain trade's practice of blending all kinds and grades of grains together. Action on these recommendations to protect the consumer of U.S. grain is a matter for future consideration. They have been opposed as too costly and not feasible by the grain industry in the past.

The "Rounding" Rule Revision: One GAO recommendation which has been implemented by FGIS, with some grain industry support, to provide fairer regulations governing permissible blending practices is the recent revision to the "rounding" rule [See, e.g., 7 C.F.R. 810.305(b), effective May 1, 1987; 51 FR 30325, August 26, 1986]. Previous practice had permitted the rounding upward or downward by 5/10 of one percent to the nearest percent and therby had encouraged the practice of blending lower quality grain with higher quality grain to meet minimum grade requirements or contractual specifications. This practice has now been tightened up by FGIS to permit rounding only to the nearest 1/10 of one percent and should have the effect of discouraging some of the more egregious blending practices which foreign and domestic buyers considered deceptive and unfair.

New Grain Variety Classification Problems: One area which impacts upon perceived grain quality is whether buyers feel they are getting the type of grain for which they contracted. The plant genetic and breeding system in the United States, often aided by incentives under the U.S. patent system, has spawned many new varieties which simply do not fit established visual characteristics for the main types of grain traded and for which specific standards exist. In addition, the U.S., unlike some of its competitors, has made a conscious public policy decision to diversify the plant germ plasm pool through the development of new varieties for fundamental food security reasons.

One of the more well-known examples of market confusion under the grain standards concerned the release of the Arkan wheat variety. Arkan, is a high yielding wheat, resistant to a number of common wheat diseases. Based on its milling and baking characteristics, Arkan is also a **hard** red winter wheat. However, visual testing of Arkan by grain classification experts often led to the classification of it as **soft** red winter wheat or **mixed** wheat. Hard, soft and mixed wheats have different milling and baking properties and end uses, as well as differing values in the marketplace.

Need for New Technologies. The Arkan example and many other examples like it leads to confusion in world markets and is an area where continuing research is being conducted by FGIS, plant breeders and other scientists to find better technologies to accurately describe the type and physical characteristics of new grain varieties. Stating the specific variety and important end-use values on the certificate would alleviate confusion. However, in order to do this successfully, spontaneous, rapid and accurate analytical technologies, appropriate to the high-volume grain trade, would have to be developed to provide verification of statements made and to promote buyer confidence.

Consumer protection and preserving the integrity of the U.S. grain handling, storage and transportation system to promote grain quality go hand in hand. Some steps have been taken by legislation to eliminate a number of the more objectionable practices of recombining foreign material and dockage in grain, tightening up rounding rules which had encouraged abuses in grain blending practices, and more accurately describing insect infestation in grain. These steps, faithfully implemented, will promote consumer protection and the integrity of the U.S. grain-handling system.

However, as we have seen, additional steps need to be taken to promote quality, including possible prohibitions of certain blending practices which lower the quality of grain and additional technology and research to cope with classification problems of the new varieties of grain and thereby instill consumer confidence. It appears that a more complete disclosure of varietal, crop year, and end-use values on official certificates will go a long way towards clearing up blending abuses and varietal confusion in the marketplace.

The Role of Other USDA Agencies in Upholding Grain Quality Standards:

Other USDA agencies also play a role in promoting grain quality from time to time. For the most part, this role is a derivative one, with grain quality determinations explicitly tied by regulation to United States Grain Standards, as administered by FGIS and discussed earlier. However, this is not always the case.

Animal Plant Health Inspection Service: For instance, USDA's Animal and Plant Health Inspection Service (APHIS) has the authority to quarantine grains to prevent the artificial spread of dangerous plant pests [See, e.g., the Plant Quarantine Act, 7 U.S.C. 161, 162 and the Federal Plant Pest Act, 7 U.S.C. 150dd, 150ff]. Such authority has been utilized by APHIS on several occasions having a positive effect on grain quality [See, e.g., 7 CFR Part 300, Part 301, Subpart--Black Stem Rust, 7 CFR 301.38 - 301.38-10; Subpart--Witchweed, 7 CFR 301.80 - 301.80-10; Subpart--Corn Cyst Nematode, 7 CFR 301.90 - 301.90-10].

Commodity Credit Corporation: The Commodity Credit Corporation (CCC) promulgates regulations governing price supports, loan and purchase programs for various grain crops, including major grain exports such as corn, wheat and soybeans. Such CCC regulations are in reliance upon authorities in sections 4 and 5 of the Commodity Credit Corporation Charter Act, as amended, 62

Stat. 1070, as amended, 15 U.S.C. 714b and 714c; Sections 101,201,301,401,403, and 405 of the Agricultural Act of 1949, as amended, 63 Stat. 1051, as amended, 10532, as amended, 1053, as amended, 1054, as amended, 7 U.S.C. 1441, 1446, 1447, 1421, 1423, and 1425, and section 107d of Public Law 99-198.

CCC loan and purchase programs establish provisions for grain quality determinations [See, e.g., 7 CFR 1421,92 (determination of quality for corn); 7 CFR 1421.367 (determination of quality for soybeans) and 7 CFR 1421,462 (determination of quality for wheat)]. These quality determinations, however, are not unique to CCC programs, but are explicitly based upon the United States Grain Standards, as implemented by FGIS.

Agricultural Stabilization and Conservation Service: Further, USDA's Agricultural Stabilization and Conservation Service (ASCS) has an indirect effect on grain quality by requiring that all ACR acreage devoted to grains and other commodities have measures taken with respect to it to control insects, weeds, and rodents [See, e.g. 7 CFR 713.64].

In addition, grain warehouses, regulated pursuant to the United States Warehouse Act, as amended [7 U.S.C. 241-273] adopt the official United States Grain Standards as the standards for all grain required to be graded under the U.S. Warehouse Act [7 U.S.C. 257; 7 CFR

736.771.

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3. Public Health: Ensuring a Safe Food Supply

Relationship of USDA to FDA Interests: Regulatory objectives to protect grain consumers from quality defects often blend or overlap with federal efforts to protect public health by ensuring a safe food supply. For instance, infestation of grain with live insects not only may result in a classification of "weevily" under U.S. grain standards administered by USDA/FGIS, but may also result in seizure of products made from that grain as "adulterated" or "insanitary" by U.S. Marshals acting under the authority of a U.S. Attorney, proceeding against the offending grain products pursuant to regulations administered by the Food and Drug Administration (FDA).

An Incoherent Regulatory Policy: However, despite the existence of a Memorandum of Understanding between FGIS and FDA, the overlap between U.S. Grain Standards and FDA regulations to safeguard the nation's food supply is not always coherent or consistent. The problem is explicitly referenced in a footnote to the individual grain standards published by FGIS. It reads as follows: "Compliance with the provisions of these standards does not excuse failure to comply with the provisions of the Federal Food, Drug, and Cosmetic Act, or other federal laws." [See, e.g., 7 CFR 810.301, footnote 11.

While this footnote may sound like an innocuous, "boilerplate" legal admonition, it masks a serious situation and defect in the existing United States Grain Standards.

To put the problem in perspective, current U.S. grain standards are basically amended versions of standards dating from as early as 1916. They have not kept pace with developments in food and drug law, nor the expanding public interest in a safer and better food supply. Accordingly, for example, it is perfectly possible to meet the requirements of the U.S. Grain Standard for Wheat regarding insect infestation, but fail the FDA defect action level for insect fragments in flour made from that wheat.

"Defect action levels" are "triggers" to FDA enforcement actions. Although defect action levels have only been issued by FDA for wheat flour in the grain and grain product area, the existence or nonexistence of such levels should not be construed as a limitation on FDA's authority to initiate an enforcement action against insanitary or adulterated grains or grain products of any type. Rather, defect action levels should be read only as a management tool for the routine initiation of enforcement actions by FDA.

Before suggesting what should be done to remedy the gap between U.S. grain standards and FDA requirements, an exposition of key public health regulations safeguarding the food supply is in order. What has been, or can be, the impact of these regulations on U.S. grain quality?

Federal Food, Drug and Cosmetic Act: The primary federal agency administering laws to protect the public health and the safety of the food supply is Food and Drug Administration (FDA). Of particular interest and importance is the Federal Food, Drug and Cosmetic Act ("FDCA") [Public Law No. 717 (1938), as amended, 21 U.S.C. 301 et seq.; implementing regulations at 21 CFR 1 et seq.], the basic food and drug law of the United States. The most extensive law of its kind in the world, many States have laws similar to the FDCA and many even have provisions to automatically add any new federal requirements.

Adulterated or Insanitary Products: Prohibited acts under FD&C of relevance to grain quality are the distribution or importation of foods that are adulterated (meaning defective, unsafe, or filthy products) or products produced under insanitary conditions [21 U.S.C. 402, 501, 601]. A food is deemed to be illegal as adulterated if it bears or contains an added, or naturally occurring, poisonous or deleterious substance which may render it injurious to health [21

U.S.C. 401(a)(1)]. Aflatoxin-contaminated corn, for example, may be illegal as adulterated by virtue of its containing a naturally occurring, poisonous, or deleterious substance which may render it injurious to health. A food is also illegal if it has been prepared under insanitary conditions whereby it may have been rendered injurious to health [21 U.S.C. 402(a)(4)].

__Color Additives, Adhesives and Coatings:__ In addition, FDA regulates several other areas with potential impact upon grain quality, including the permissible type of color additives which may be added to grain for identification purposes [21 U.S.C. 371, 376; 21 CFR Parts 70-99] and the permissible type of adhesives and coatings which may come in contact with grain being transported in railcars, barges and other modes of transportation [21 U.S.C. 321(s), 348; 21 CFR Part 175].

__Insect Infestation of Grain Under FDCA:__ In view of the recurrent problem of insect infestion of grains, the sanitation provisions of FDCA are particularly important. Prohibited are food products which may contain repulsive or offensive filth, such as whole insects, insect parts and excreta, as well as other extraneous, repulsive materials which would not knowingly [illegible] eaten or used.

It [illegible] important to note that fumigation or treatment of grains already infested with insects does not make the grains legal under FDCA requirements since dead insects or evidence of past insect activity is also objectionable and repulsive and is evidence of adulteration and insanitary transportation, handling, and distribution conditions for the grain. While some fumigants and other chemicals may be employed as preventives to keep wholesome grains from becoming infested, especial care is required to prevent fumigant and other chemical residues from exceeding permissible tolerance levels, thereby also triggering possible federal seizure.

Pesticide Residues on Grain: In this regard, in addition to the above FDCA requirements, FDA also enforces FDCA requirements complementary to EPA's functions under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). Raw agricultural products, including grains, are illegal if they contain residues of pesticides not authorized by, or in excess of, safe tolerances set by regulations of the Environmental Protection Agency (EPA) and enforced by FDA [21 U.S.C. 408]. Premarket testing and approval of products made from grains is performed and, if tolerances are exceeded, those products must be removed from the market.

Tolerances for Pesticides: "Raw agricultural commodities" are defined by FDA to include grains and violate FDCA if they contain a pesticide which has not been exempted from the requirement of a residue tolerance, or if they exceed a residue tolerance which has been established for a particular pesticide. Any processed food made from grain does not violate residue tolerances if the residue in the processed product does not exceed the tolerance established for the raw grain. [21 U.S.C. 408; 21 CFR 180, 193].

Good Manufacturing Practices: FDA also publishes Good Manufacturing Practices (GMPs) to give guidance to firms in meeting FDA sanitation requirements in food establishments. The GMPs specify building types, maintenance procedures, equipment, errors to avoid, vermin control and other practical steps to ensure sanitation. Although most grains are intended to be processed into food products, processing and manufacture alone does not relieve the raw grains from federal requirements of cleanliness and freedom from deleterious, harmful impurities.

Nondeleterious Defect Action Levels: While the FDCA does not provide for tolerances for filth such as insect fragments in food, FDA has recognized that many agricultural products cannot be grown entirely free of natural defects, such as infestation. Accordingly, FDA has published a series of "defect action levels" for food products, stating amounts of insect fragments, rodent hairs, and other objectionable items which must be found in food before an enforcement action is triggered [U.S. Department of Health and Human Services, Public Health Service, Food and Drug Administration, Bureau of Foods, *The Food Defect Action Levels,* HHS Publication No. (FDA)83-2161].

USDA: Falling Behind on Public Health? FDCA requirements have kept pace with today's sophisticated consumer, who has an increasing health consciousness and concern for the safety and healthfulness of food. That consumer would be shocked to learn that wheat meeting the minimum requirements of the United States Grain Standards could not produce a legal or safe wheat flour under FDCA requirements. It is obvious that USDA/FGIS grain standards have not kept pace with public health developments.

Reconciling FDCA and USDA Regulations: Looking to the future, as consumerism, public health, and the "right to know" regulatory movements continue to grow and gain strength, the U.S. grain standards, as presently written, will increasingly be living on borrowed time. What can be done to address this problem, and bring the U.S. grain standards up to date with modern food and drug regulatory developments?

A Zero Tolerance For Infestation: The most fundamental action which has been taken, and which continues to be taken, is to consider the establishment of a zero tolerance for insects in grain. If this were done, U.S. grain could better comply with FDCA requirements. The discrepancy between public health protection and grain trade facilitation could be thereby eliminated.

Background: GAO has investigated the subject of insect infestation and recommended that U.S. grain standards should not have a tolerance for insects. Live or dead, insects are objectionable. GAO pointed to the fact that insect infestation is one of the chief sources of foreign complaints about the quality of U.S. grain and to the fact that domestic food processors face the possibility that their products made from infested grain can be seized, even though the grain was certified as meeting U.S. Grain Standards.

GAO noted that, while FGIS attributed most of the infestation problem to hidden or latent infestation, GAO found that FGIS' instructions and criteria for testing for infestation and certifying the extent of infestation were also causes of the problem. Accordingly, section 304 of the Grain Quality Improvement Act of 1986 mandates FGIS to issue a final rule revising grain inspection procedures and standards to more accurately reflect levels of insect infestation.

Other actions taken to date on the subject of insect infestation include internal USDA research reports which found that grain exported from the U.S. contains a significant incidence of undetected, latent, or undeclared insect infestation and suggested that insect tolerances in grain be reevaluated. In addition, GAO has recommended a zero tolerance for live insects in U.S. grain and FGIS has held series of public meetings to discuss this possibility.

Controversy and Opposition: The zero-tolerance concept was vigorously opposed by the grain-handling industry, but strongly supported by domestic processing industries and foreign buyers since a zero tolerance was responsive to their complaints of excessive insect infestation.

Bowing to pressure from some in the grain industry, FGIS later denied that the zero tolerance infestation proposal had ever passed beyond the talking stage and had never been formally proposed for public discussion. In fact, FGIS eventually removed the infestation issue from its official regulatory review agenda.

However, an Insect Infestation Task Force continued to meet within FGIS. On June 26, 1985, it issued a report describing 33 insect-related problems and suggested ways to better FGIS detection, identification and certification of insects in grain. Included was a recommendation that FGIS evaluate the impact of a zero insect tolerance. An interagency task force was established to discuss the insect infestation problem, particularly with a view towards establishing communication and consistency between FGIS and FDA requirements.

Much remains to be done in this area but it is clear that increased public awareness of the insect infestation reality will increase the pressure for zero insect tolerances in grain and grain products. Defenders of the existing insanitary practices which permit infested grain will eventually be forced to choose between the improvement of grain quality through better grain management practices, or increased liability exposure as the public becomes intolerant of dirty, infested grain as the source of their daily food staples.

4. Environmental Protection: No Quick Fix, No Free Ride

Hand in hand with the domestic regulatory objective of protecting public health by ensuring a safe food supply is the protection of the environment through regulation of agricultural activities from the farm to the consumer's table. The issues of major public concern involving stewardship of the environment throughout the food chain have both short and long-range impact upon environmental quality, public health, and the economics of the grain business.

The Pesticide Problem: These issues involve the extensive use of pesticides (insecticides, herbicides, fungicides, and rodenticides) on grains at various points from the farm, through storage, handling, transportation, processing, and distribution. Of particular interest and concern is the use of grain fumigants on insect infestations, and preventive chemicals for insect infestations.

Chemicals used extensively in the U.S. to destroy or control weeds, insects, fungi and other pests have increased from 320 million pounds in 1964 to approximately 1 billion pounds today. Although such chemicals contribute significantly to agricultural productivity, there is growing concern that these chemicals may cause equally significant adverse effects upon human health. Pesticides have been found to cause chronic health consequences such as cancer, birth defects and genetic damage. Many persist in the environment for extremely long periods and gradually accumulate in the tissues of plants, animals and humans. The most noteworthy example of this concern was the recent scare involving ethylene dibromide residues in grain-based consumer products.

"Permissible" pesticide residues and tolerances in grain and in food products made from grain are a matter of increasing public concern. Increasingly, the "right to know" regulatory movement is demanding, and will continue to demand to know exactly what chemicals were used, when, and in what quantities at all stages of the life cycle of grain, from the farm to the consumer's table. Similar to the hazard communication regulation of chemicals through detailed disclosures on "material safety data sheets", responsible future food disclosure regulations increasingly will require pesticide and pesticide residue testing data and information.

Groundwater and Run-Off: In addition to the dangers of various chemicals in grain-based foods, ecosystem integrity and safety of the potable water supply is being endangered gradually through the use of chemicals on grain in the fields. The contamination of the groundwater in large sections of the productive agricultural belt is of vital concern. In addition to groundwater contamination, most of non-point source pollutants in national river basins, adversely impacting water quality, comes from agricultural run-off.

No Quick Fix, No Free Ride: Each of these problems, the legal and regulatory regimes for solving them, and the implications for grain quality will be discussed in the subsections which follow. As we shall see, there is no quick fix, and no free ride for American agriculture in dealing with the solutions to these problems. Like other industries that have absorbed the cost of pollution controls as costs of doing business, grain-producing industries will increasingly have to do the same. Alternatively, increasing public and private investments will have to be made in genetic research to breed varieties of grain which are resistant to pests and disease, obviating the need for chemical pest management and chemical residue removal.

Federal Regulation of Pesticide Residues:

Background: Although efforts to regulate chemical pesticides at the federal level began as early as 1910 with the enactment of the Federal Insecticide Act, it was not until the 1970s that environmental protection became a domestic federal regulatory priority. While the 1910 statute was replaced with the Federal Insecticide, Fungicide and Rodenticide Act in 1947 (FIFRA), FIFRA's original purpose was to protect agricultural consumers from ineffective products. While this consumer protection objective is still a part of FIFRA, it is fair to say that with the extensive 1972 amendments to FIFRA, its transformation into an environmental protection statute was complete [Federal Environmental Pesticide Control Act of 1972, Public Law. No. 92-516; implementing regulations at 40 CFR 162 et seq.]. The metamorphosis of FIFRA had been guaranteed from the moment jurisdiction for FIFRA was transferred from USDA to EPA upon the creation of EPA in 1970. Under the FIFRA provisions administered by EPA today, no manufacturer or importer may make or sell a product for use to control pests unless that compound has been registered with EPA.

EPA, FDA and Residue Tolerances: A major expansion of the regulation of pesticides occurred in 1954 with amendments to FDA authority under the FDCA which gave FDA the power to adopt and enforce pesticide residue tolerances or allowable limits for residues of pesticides on food, including grain. Tolerance levels, or the amount of pesticide that can remain on a crop at after harvesting, are legal enforcement levels established by EPA, which are usually set well below, normally 100 times below, the level at which the pesticide might cause harm to people or to the environment.

Requirements for Registration with EPA. In order for pesticide products to be registered with EPA, chemical manufacturers must submit test data concerning environmental effects, including toxicological studies, residue points and other studies with respect to the uses of the product for which approval is requested.

Included among information which must be required are data on potential for skin and eye irritation, hazards to non-target organisms, such as wildlife and fish, possibilities for acute poisoning, tumor formation, reproductive impairments, birth defects, other serious health defects, the behaviour of the chemical in the environment after its application, and the amount and type of residues likely to occur in food and feed crops.

Products registered for an approved use cannot be sold or used for other purposes without reregistration. Since products are registered with EPA based upon chemical composition and use, selling pesticides for new uses, changing ingredients or percentages of ingredients will all require EPA approval additional test data and studies.

Re-registration of Older Pesticides: Of particular interest and importance to the grain industry and grain quality is FIFRA's requirement that pesticides in use prior to the 1972 amendments must be reregistered wiith EPA to ensure that they meet current safety requirements. Products which pose unreasonable adverse effects to the water, air, land, plants, humans, other animals, and thhe interrelationships among them must by law be denied reregistration by EPA or have their existing registrations cancelled.

__Impact on Grain Fumigants and Protectants:__ The reregistration and registration cancellation processes are very important with respect to grain fumigants and protectant chemicals for insect infestation of grain. EPA concerns about the potential adverse effects of ethylene dibromide (EDB), ethylene dichloride, carbon disulphide, carbon tetrachloride and other liquid grain fumigants, such as chloropicrine, resulted in requests to chemical manufacturers for additional information and studies. Given the costs of these studies, chemical manufacturers declined and gave up EPA registrations for fumigant uses. Potential health effects and an inadequate market to justify expenses of reregistration resulted in the voluntary cancellation of registrations for these products.

This development has placed the grain industry, which had enjoyed a "quick fix" to the insect infestation problem through the use of liquid grain fumigants and a relatively free ride on environmental regulatory compliance costs, at a loss to effectively deal with the infestation problem. Currently, one of the few legal grain fumigants is aluminum phosphide, a gas which takes four days to work effectively and which only works effectively in airtight enclosures (which do not normally exist in the grain industry) due to its rapid dispersion characteristics.

Accordingly, due to these developments, the grain industry, in its strategic planning for the future, should not count on the replacement of liquid grain fumigants with new compounds as a solution to the insect infestation problem. Other EPA initiatives concerning fumigants, and the detection of 1,3-dichloropropane in groundwater points to the continuing attrition and disuse of grain fumigant materials.

Increasing Use of Grain Protectants: Cancellation of grain fumigant registrations has caused a movement toward the application of protectant chemicals, dry or liquid, such as malathion, to grain. These preventives are useful in keeping infestations from occurring, but do not kill existing infestations as do fumigants.

The Problem With Protectants: While the [illegible] application of these chemicals is motivated by the desire to preserve the quality of grain during the handling, storage, and distribution process, the problem with this approach is that the use of preventives are resulting in low levels of pesticide residues which persist in grain and in products made from grain. The long term effect of such low level residues of malathion and other chemicals in the diet is simply not known.

Herbicides: Similar developments have occurred with regard to common herbicides, with EPA cancelling registrations of chemicals formerly used to control weeds, garlic, and other plants which adversely affect grain quality. Accordingly, high numbers of weed seeds, garlic bulbs, and other noxious herbaceous elements are appearing in grain, with a negative impact on quality.

Grain Quality Without Chemical Management? In view of these developments in pursuit of environmental regulatory objectives--resulting in the loss of most of the common pest management tools--the grain industry and U.S. agriculture is faced with a situation where the necessary pest management tools have been removed and the quality of grain in storage is likely to be adversely affected by increased insect infestations.

While, as discussed above, this has increased the use of grain protectant chemicals to prevent infestations from occurring, most agricultural extension and pesticide regulatory officials do not believe that non-fumigant control strategies also will prevent insect infestations. What then is the solution to promote grain quality while preserving environmental regulatory goals?

__Need for Technology and Research:__ Clearly, there is crying need for new technologies to prevent and control insect infestation. While gene transference in grains is now difficult, there has been some success in breeding disease and insect resistant breeds, obviating the need for external chemical control.

In addition, an emphasis on manual cleaning measures, pre-bin cleaning and treatment, aeration cooling and other techniques should reduce the overall frequency and severity of insect infestations in the grain handling system. Furthermore, other new technologies to control infestation involve the heating of storage structures to 130 degrees F, and the use of "freeze-outs".

__Looking Ahead: Few Chemical Options.__ Congressional pressure in response to public concern has been increasing in recent years for EPA and FDA to more effectively regulate pesticides and other chemicals, such as grain fumigants, which affect the safety of the food supply.

In this regard, GAO has examined both EPA's responsibilities to register pesticides in an April 18, 1986 report entitled __Pesticides: EPA's Formidable Task__

To Assess and Regulate Their Risks [GAO/RCED-86-125], and FDA's responsibility to enforce the FDCA prohibition against the marketing of foodstuffs which exceed legal pesticide tolerances in an October 27, 1986 companion report, Pesticides: Need to Enhance FDA's Ability to Protect the Public From Illegal Residues [GAO/RCED-87-7].

In view of GAO findings that the scope of EPA and FDA review and enforcement is limited by a number of factors, both legal and practical, it is certain that public apprehension about the safety of the food supply will continue to increase and additional regulatory requirements established to better enable the attainment of domestic health and environmental goals.

Interagency Examination of Grain Fumigation: Special attention has been paid to the subject of grain fumigation. As GAO found in its September 1981 report to the Interagency Regulatory Liaison Group, Grain Fumigation: A Multifaceted Issue Needing Coordinated Attention, [GAO/CED-81-152], grain fumigation involves environmental, consumer, and worker protection, transportation, and food safety considerations. Despite many years of using fumigants as a means to rid grain and grain products of insect infestation, and despite the involvement of numerous government agencies in aspects of fumigation, workers continue to be exposed to potentially unsafe fumigant levels, fumigant residue has been found in some food products, GAO recommended an interagency group tackle the issue of grain fumigation and develop policy alternatives.

USDA Increases Involvement in Pesticide Review: Since the GAO report, with the withdrawal of major fumigants from the market and with increased concern about pesticide residues in food products, USDA has now become more involved and active in the pesticide review process through an interagency committee of EPA, FDA and USDA officials. The committee coordinates federal regulatory activities under FIFRA. As the chemical tools to control grain infestation diminished, USDA came to realize that EPA was increasingly impacting its vital interests.

More active USDA involvement in the interagency process is an important development since USDA can bring to the process its knowledge of economic and social benefits of a particular pesticide for a particular crop. This will provide more balance to FIFRA's unusual requirement that EPA consider not only the risks, but also the benefits, of a particular pesticide. For example, in certain circumstances under FIFRA, EPA can decide to continue to allow the use of a pesticide which poses a significant risk to the environment or to human health, but which is the only available defense against a particular pest on a valuable cash crop.

With active USDA input, EPA will better be able to decide to allow continued use of a pesticide or fumigant under certain, limited circumstances. This would be a classic balancing of risks and benefits under FIFRA, where economic and social benefits of a cash crop are determined to outweigh risks posed by a particular pesticide.

__State and Local Regulation:__ However, the grain industry cannot afford to look to USDA and the interagency pesticide review process to be its salvation in preventing the attrition of additional grain fumigants and grain protectants. This is true since, at present, FIFRA does not preempt state and local regulatory efforts governing pesticide residue levels so long as the state regulations meet federal minimum requirements. The states are free to impose restrictions which go beyond federal requirements and, indeed, a number have done so.

__The Liability Problem:__ In addition, with the proliferation of state and local "right to know" laws, coupled with the explosion in products liability litigation, it is only a matter of time before principles extended to other articles in our society are also extended to grains and to products made from those grains. Indeed, one of the great unresolved issues in the FIFRA debates of the 99th Congress and which remains for Congressional consideration during 1987 and 1988 in the 100th Congress is the question of legal liability for damages caused by pesticide use.

Groundwater Contamination:

Scope of the Problem: Groundwater is an extremely important natural resource with over half of the U.S. population relying on it for their primary source of drinking water. Groundwater supplies roughly one fourth of all fresh water used for all purposes in the U.S., and two fifths of all irrigation water. The degradation of underground aquifers, both actual and potential, has been a matter of increasing concern during the last ten years and is only partially understood.

As if the problems of pesticide residues such as EDB in grain products, and the cancellation of most grain fumigants were not enough trouble in themselves--without even considering their eventual effects on aquifers--the nascent problems of groundwater contamination and agricultural run-off are potentially even more serious. In the future, when a "galvanizing event" akin to "Love Canal" or "Three Mile Island" occurs in the agricultural heartland of America--demonstrating the potentially irreparable poisoning of a fertile aquifer through groundwater contamination rendering the area unfit for farming--the groundwater issue will have arrived full force on the public scene and national consciousness.

Needless to say, this will upset the applecart of so-called modern farming practices in rural America, often heavily dependent upon chemical inputs in the form of pesticides, herbicides and fertilizers. Looking to the future, however, in all likelihood such a galvanizing event will occur, triggering public outcry and legislative measures for more restrictive regulations of chemicals introduced into the environment. In this regard, the detection of 1,3-dichloropropane and other pesticides in groundwater does not bode well for continuing reliance upon chemical means of control for insect infestation of grain.

Seriousness of the Problem: The contamination of an aquifer is extremely costly to correct. In view of the protracted effects of contamination and nonaccessibility of the contaminated soils and waters, the restoration of groundwater resources is very difficult and expensive. Management alternatives for an aquifer in danger of contamination are (1) to treat water withdrawn from it before use, (2) to reclaim the aquifer after contamination, and (3) to totally protect the aquifer from all possible contaminant sources.

Because restoration costs will usually exceed short term value of the resource where there are alternatives available, it is clear that the most viable means to protecting groundwaters from contamination is prevention of contamination, rather than cure [EPA, Protection of Public Water Supplies from Ground-Water Contamination, EPA/625/4-85/016 (1985)].

Regulatory Regime for Groundwater: Although EPA involvement in groundwater protection is limited to the drinking water aspects of the issue, groundwater for irrigation is under the jurisdiction of the Department of Interior. It is interesting that, even though the nature and importance of groundwater is vital, no single comprehensive piece of federal legislation has been passed to protect groundwater exclusively.

Instead, federal authority to regulate groundwater quality is embodied in at least eight statutes, including the National Environmental Policy Act of 1970 [Public Law No. 91-190, as amended], the Federal Water Pollution Control Act of 1972 [Public Law 92-500, as amended], the Toxic Substances Control Act of 1976 [Public Law 94-469, as amended], the Resource Conservation and Recovery Act of 1976 [Public Law 94-580, as amended], the Clean Water Act of 1977 [Public Law 92-500, as amended], the Surface Mining Control and Reclamation Act of 1977, the Safe Water Drinking Act of 1979 [Public Law 93-523], and the Comprehensive

Environmental Response, Compensation, and Liability Act of 1980 ("Superfund") [Public Law No. 96-510].

Groundwater Residue Program Proposed: The 1986 Congressional debates concerning the FIFRA reauthorization sought to grapple with the problem of groundwater contamination by proposing a new program for the regulation of pesticides in groundwater. Under the FIFRA reauthorization as then-proposed, EPA would be required to issue "ground water residue guidance levels" ("GRGLs" or "Gurgles") for all pesticide registrations where a potential for leaching exists. EPA would also be required to announce "Gurgles" if a pesticide is detected in the groundwater of three differing geographical areas or in any drinking water well serving a significant population [Congressional Record, October 6, 1986, page 15286 et seq.].

The Agricultural "Run-Off" Problem: Coupled with the problem of groundwater contamination is non-point source run-off from agricultural sources into the nation's streams and rivers. EPA, which has done an admirable job in cleaning up point source pollution in the nation's waterways under the Clean Water Act, has estimated that at least half of the pollutants entering national river basins come from agricultural non-point sources. "Agricultural run-off which carries topsoil rich in herbicides, pesticides, fertilizers and animal wastes is a major pollutant contributor in nearlly 70 percent of national river basins" [EPA, Implementation Planning for Control of Agricultural Pollution: Institutional and Financial Issues and Approaches, August 1981].

As part of its activities under FIFRA, EPA seeks to estimate pesticide concentrations in agricultural run-off into surface waters as part of the assessment of the dangers to humans, fish and wildlife during the pesticide registration process. EPA has developed new methodologies for the accurate screening of concentrations and exposures for the various agricultural chemicals submitted for registration and reregistration. As methodologies improve to more accurately measure agricultural chemicals in surface waters, as well as exposure levels over time, it is likely that more chemicals used as a matter of course on the farm will be withdrawn from the market.

Interagency Considerations: EPA and USDA have been working together recently in an interagency effort to explain the danger of groundwater contamination and agricultural run-off. USDA is making available its county extension network to EPA in order to get the message out to farmers concerning the dangers involved. In addition it should be noted that the issue of liability for such contamination has still not been resolved. When liability is assigned for such contamination, it will, by all indications, be astronomical.

5. Occupational Safety: A Dust-Free Atmosphere

Background of the Problem: For many years, and after many deaths of grain industry workers due to grain dust explosions, the control of fugitive grain dust emissions has been a goal of the grain-handling industry. In addition to the regulatory interest in occupational safety for grain workers, the regulatory interest in clean air also militates in favor of dust emission control. Accordingly, both EPA and the Occupational Safety and Health Administration are involved in the regulation of grain dust emissions.

Particulate Emissions Into the Atmosphere:

From EPA's perspective in controlling particulate emissions into the atmosphere under the Clean Air Act, grain-handling facilities are important sources of fugitive emissions to be controlled. The particulates in question are mainly grain dusts which may be comprised of 60-90 percent organic material, 3-20 percent inorganic materials, such as free silicon (sand from entrained dirt). The particulates may include particles of grain kernels, spores of molds and smut fungi, insect fragments and droppings, chemical residues, and pollen.

Fugitive Emission Controls. The primary emission control technique for grain dust is the use of fabric filters in baghouses which are 99% effective and do not produce visible emissions. Dusts collected in these filters are often added back to the grain to adjust the quality of the mixture. [See, e.g., EPA, Office of Air Quality Planning and Standards, Review of New Source Performance Standards for Grain Elevators, EPA-450/3-84-001, January 1984].

Controlling Explodable Atmospheres:

The OSHA interest in controlling grain dusts is to prevent atmospheres approaching the lower explodable limit (LEL) for grain dust from occurring. More potent than TNT, grain dust has caused many tragedies in the grain industry throughout the years, causing significant loss of life. Pneumatic system collectors remove dust from the atmosphere and collect it in fabric filters in baghouses to maintain a safe working environment for grain industry workers. However, much of this dust is later added back to the grain at various points during the grain-handling process.

Although the Grain Quality Improvement Act, discussed above, will prohibit this practice at export elevators, the addition of dusts back to grain, originally collected for safety or clean-air reasons, can occur at any point during the distribution and storage chain prior to arrival at the export elevator, or, for that matter, in the export elevator itself prior to official weighing and inspection. Therefore the provision is, in reality, of limited practical effect since its enforcement may be totally or partially obviated.

Grain exporters have historically strongly objected to any possible meaningful prohibition on the return of grain related materials, such as grain dust, back to the grain stream after it has been removed. In the exporters' view, "A prohibition on the recombination of dust with grain would do one of two things: cause the dust to always be marketed separately, or cause the aspiration-type dust control systems to be abandoned, probably in favor of oil-additive systems" [Commitment to Quality: A Consensus Report of the Grain Quality Workshops, June 1986].

Oil-Additive Dust Suppression Systems: It is interesting to note that the exporters' prediction has begun to come true with increased recent usage of vegetable oils as dust suppressants. Vegetable oil treatments are quite effective in controlling grain dust to achieve occupational safety and particulate emission control regulatory objectives.

However, the use of vegetable oils as dust control measures is still controversial and may not be appropriate for grain quality and health reasons primarily related to pesticide residues.

First, since the usage of vegetable oils to control grain dusts is relatively new, apart from the use of edible vegetable oils, there is no specific FDA standard regulating the use of vegetable oils for this purpose. In addition, there have been allegations that crude, crude degummed, and refined edible oils have all been used.

An additional problem is that oils cause the adherence of grain dust, comprised of weed seeds, free silica, insect fragments and excreta, and many other objectionable items, to the grain, which is objectionable. In addition, reduced milling and baking yields, color problems, and rancidity have been reported, as well as problems with grain-handling, as well as milling and baking equipment.

While the addition of mineral oil as a grain dust suppressant is more closely regulated by FDA, vegetable oil usage does not require specific FDA approval. Further, FGIS' grain inspection system does not require the reporting of oil added at various stages of the grain-handling and distribution process. Accordingly, it is difficult to say how much oil may be present in grain at the point of export.

The worst problem associated with the use of oil as a dust suppressant, however, is due to the fact that grain protectant chemicals, such as malathion, are concentrated in the grain dust, being typically 8 PPM in grain and 50-100 PPM in grain dust. Pneumatic baghouse systems remove the dust and thereby reduce the PPM of objectionable chemical residues present in grain. Thereafter, the residue-rich dusts can be recovered for energy value or disposed of under applicable environmental resource provisions. Specifically, grain dusts, collected in pneumatic dust control systems, could be considered solid wastes pursuant to section 6903(27) of the Resource Conservation and Recovery Act (RCRA) [Public Law 94-680, as amended by Public Law 98-616] and could be recovered for their energy value or disposed of as solid wastes in accordance with RCRA provisions.

However, oil-additive dust suppression systems ensure the adherence of greater PPM of malathion and other chemical residues directly to the grain. This fact could present a future problem to the grain-handling industry should litigation be filed against it under any number of the strong state and local "right to know" laws, or under various products liability legal approaches.

As such, utilization of oils as a dust control technique may not enhance the regulatory goals of grain quality, public health or food safety. Needless to say, if dusts from pneumatic bag houses are added back to the grain in any event, there is no net difference in chemical residue PPM between aspiration and oil-type systems of dust control.

6. Recommendations and Conclusions

As we have seen in the sections above, competing domestic regulatory objectives involving consumer protection, trade facilitation, public health and the safety of the food supply, environmental protection, and occupational safety all have an impact on the quality of grain marketed and sold in the United States and for export markets. Several conclusions can be made about the effects of domestic regulatory policies on U.S. grain quality.

First, domestic and foreign consumers of United States grain do not appear to be well served by the United States Grain Standards Act as administered by FGIS. The consumer protection goal of the United States Grain Standards Act, as amended, suffers while the trade facilitation goals of the Act predominate. In this regard, (1) the origin of the grain standards as trading rules in the early part of the century, (2) the underutilization of open decision-making processes under existing authorites, affording equal access for all interested parties, and (3) the lack of any meaningful complaint procedure for foreign buyers of U.S. grain, as well as for domestic processors and industry, are all factors discussed above which reinforce this conclusion.

Second, in order to enhance U.S. grain quality, the United States Grain Standards need to be rewritten to reconcile and conform them with modern regulatory developments in the areas of public health, environmental protection, and the safety of the Nation's food supply. As shown in the discussion, the inability to often process legal products under FDA requirements from grains meeting minimum U.S. Grain Standards, is testimony to the fact that U.S. Grain Standards have not kept pace with modern regulatory developments. Specific revisions discussed to promote grain quality, while reconciling and conforming the standards with domestic public health, environmental and food safety regulatory objectives are four-fold:

1. **Blending Practices:** Revised standards should explicitly, clearly, and without exception prohibit the blending of good or high quality grain with poor or low quality grain; prohibit the blending of dirty grain with clean grain to produce seemingly clean grain. Revised standards should eliminate the incentive for gamesmanship to produce the lowest common denominator grain meeting minimum standards or contractual requirements.

2. **Reintroduction of Dusts and Foreign Material:** Revised standards should explicitly, clearly, and

without exception prohibit the reintroduction of grain dust, foreign material, or other non-grain materials, removed by dust control systems, back into cleaned grain to adjust the quality of the grain, or the introduction of such or similar materials from whatever source into grain. It is time that we simply recognize the fact that, under food and drug law principles, existing U.S. Grain Standards have permitted adulteration of grain. This revision would bring the grain standards up to date by making it the law to take the trash out and keep it out.

3. **Zero Tolerance for Insects, Dead or Alive.** Revised grain standards should establish no tolerances whatsoever for insects, dead or alive. This would bring the standards up to date with FDA requirements prohibiting adulteration and insanitary foodstuffs.

4. **All U.S. Grain Should Be Pneumatically Cleaned.** This is the most fundamental revision of all. Not only would such a revision create a U.S. reputation for quality grain, which is now sorely lacking in comparison to U.S. competitors, but also such a revision would remove from grain objectionable elements contained in grain dust. These elements include insects, insect fragments, insect, bird and rodent excreta, and chemical residues from grain protectants which concentrate in the grain dust. In this regard, the utilization of oil-

additive dust suppression systems--which adhere chemical residues and other objectionable elements in grain dust to the grain without cleaning the grain--should be prohibited unless a method is provided to remove toxic residues and other objectionable components of grain dust.

Third, potential environmental and public health concerns raised by pesticide use (1) as residues on grain products which can be ingested, and (2) as contaminants to groundwater aquifers and (3) as pollutants to surface waters through agricultural run-off, will continue to restrict--and probably eventually prohibit--their continued use to "enhance" grain quality by controlling insect infestations. The cancellation of grain fumigants has caused a movement toward the increased use of grain protectants. Both cause harmful residues, the ingestion of which over the long-term in the diet is unknown. Since grain protectants tend to occur in grain dust in much higher concentrations, this underscores the need for the pneumatic cleaning of grain and proper disposal of grain dust. Both the food residue and groundwater contamination aspects of the continuing use of chemical controls are potential sources of considerable legal liability, also underscoring the merit of cleaning grain.

Fourth, the serious problems of pesticide residues and groundwater contamination underscore the need for regulatory policy to promote alternative technologies of insect control, and for research to place increased emphasis on breeding insect and disease resistant grain varieties. Pre-bin cleaning, aeration cooling, heating storage structures, freeze-outs, and other methods to prevent and control insect infestations should be utilized. A national research effort is needed to develop new, non-toxic means of pest control.

Fifth, as shown in the discussion above, domestic regulatory objectives of consumer protection, public health, environmental protection, and occupational safety are not in conflict with the goal of promoting U.S. grain quality. Revising the U.S. Grain Standards to be consistent with these other domestic regulatory objectives will serve notice on the world that the United States has established QUALITY CONTROL as a new regulatory objective for the most fundamental staples of its food supply--its grains.

Needless to say, some changes to the United States Grain Standards Act may be appropriate to effectuate the above conclusions and recommendations. However, in view of the broad authority granted to the FGIS Administrator under the United States Grain Standards Act, as amended, many, if not all, of the necessary changes could be accomplished by regulation and through a different emphasis on the plain language of the statute.

What would be necessary to accomplish this would be the political will to truly effectuate quality control as the primary regulatory objective of FGIS. While the Grain Quality Improvement Act of 1986 was a step in the right direction, as the congressional debates established at the time, sponsors openly doubted whether it would accomplish its objectives. Clearly, as we have seen in the earlier discussions, the blending exception to the quality improvement amendments vitiates its utility in accomplishing the objective of the Act.

Forward-thinking individuals in the grain industry, however, think it is high time that the U.S. clean up its act, clean its grain, and change its image to that of a quality supplier second to none. Bringing the U.S. Grain Standards up to date to be consistent with the requirements of other modern domestic consumer, health, environmental and safety regulatory policies can significantly contribute to the accomplishment of that objective.

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Background Paper No. 4

Analysis of the United States Grain Standards

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U.S. GRADES AND STANDARDS -- PRINCIPLES AND ISSUES

Grades and standards facilitate marketing by providing a common language for communicating information about quality and value. Marketing efficiency requires a system of descriptive terms that enable purchase and sale of the commodity by description rather than by inspection. The sale of millions of bushels of grain by phone and telex would not be possible without the common language of grain standards. Since most commercial transactions use only one or two grades the many diverse qualities produced by nature and farm practices are combined into a few relatively uniform standardized categories during the marketing process. However, the move toward a uniform product conflicts with the profit maximizing principle of product differentiation. Private gains from product differentiation are offset by aggregate losses in efficiency of market transactions. It is not surprising to find individual exporters and domestic grain handlers unwilling to support new standards or changes in grades despite the evidence that the industry in total would benefit from change. Measures of oil and protein in the soybean standards may logically meet opposition from individual firms whose individual profit depends on being the first to identify sources of soybeans with oil content above the average for that crop year.

Uniform grades and standards provide equal access by all buyers and sellers to information [illegible] firms to compete on the basis of operating efficiency rather than on the control of information. The inability to gain acceptance of voluntary standards prior to the 1916 United States Grain Standards Act can be traced to the conflict between market opportunity for individual firms through product differentiation and the efficiency of marketing associated with product uniformity. Only through nationally enforced grades and standards could individual firms reap the benefits of the industry-wide market efficiency emanating from uniform grades and standards.

The 1916 U.S. Grain Standards Act (USGSA) and subsequent amendments and regulations have established two areas of responsibility for the Federal Grain Inspection Service of the USDA (FGIS):

1. to establish uniform grades and standards for all grains.
2. to conduct and supervise inspection procedures to assure accurate and unbiased results.

Inspection Regulations

The USGSA requires that FGIS develop standards and maintain a national inspection system. This inspection system is comprised of FGIS offices with Federal inspectors located at major ports, 72 designated State and private agencies located in the interior of the United States, and 8 delegated State agencies at ports not serviced by FGIS. FGIS administers field offices scattered throughout the country to oversee the activities of State and private inspection agencies.

All non-federal employees employed by State and private agencies authorized to perform inspection on FGIS' behalf must pass examinations on grading proficiency and be licensed. These individuals can be licensed to inspect one or more of the grains for which standards have been established. In no instance, however, can individuals perform official inspections unless they hold a valid license for that grain. As of September 30, 1987, there were 753 licensed inspectors employed by these agencies.

In addition to developing standards and providing inspection services, FGIS develops and publishes inspection procedures; evaluates and approves inspection equipment that must be used during inspection; monitors inspection accuracy of FGIS' employees and licensed inspectors; periodically tests sampling and inspection equipment for accuracy; provides appeal inspection; and responds to complaints regarding service. FGIS also audits its own activities to ensure that service is being provided on a nondiscriminatory basis and that no licensed individual has a conflict-of-interest.

Private Inspection

Inspection services using the grain standards established under the USGSA may be performed by grain company employees or by private companies not affiliated with FGIS. Grain received from farmers is very seldom graded by licensed inspectors, but by the employees of the elevator or processing firm. Since these are not official inspections, the factors graded, the discounts, and the break points for discounts are at the discretion of the individual buyer subject to competitive forces in the market. Equipment used by these firms is generally the same as that required by FGIS and the standards by which quality is determined follows the regulations promulgated under USGSA. Intercompany transfers and sales between firms may also be conducted without the benefit of official grades. Only export grain is required by law to carry an official USGSA grade designation.

The standards established under the USGSA are generally used as the basis for inspection by company employees inspecting grain. FGIS procedures may or may not be followed based on individual company policy. Equipment and inspection accuracy is not monitored unless the company has established an internal monitoring program. In many cases, inspectors compare their inspection results to results obtained by FGIS or an FGIS licensed inspector on the same grain in an effort to ensure accuracy. Either buyer or seller may request an official inspection by a licensed inspector if the results of the company employee is in question. However, neither party is required by law to abide by the inspection results.

Export Inspection

The USGSA requires that all grain being exported be inspected by FGIS inspectors or an FGIS delegated State agency. The only exception to this rule is grain moving into Canada and Mexico by land carrier and for small exporters who ship less than 15,000 metric tons in a given year. In 1987, only 37 such exceptions for small exporters were requested and granted.

Even though FGIS is required to inspect all grain being exported, overseas buyers often request private companies located here in the United States to represent their interests and inspect the grain as it is being loaded. Inspections performed by private companies can include inspection for grade as defined by grain standards established under the USGSA or for factors not covered by these standards such as falling number in wheat or oil and protein in soybeans. In cases where private companies perform inspection using the grain standards, two groups issue inspection certificates: FGIS and the private company.

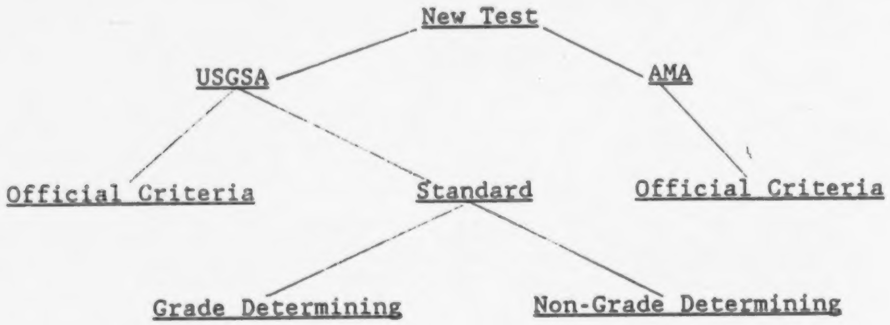
Samples obtained by private companies are often submitted to FGIS for analysis and grade. When samples are submitted to FGIS, FGIS' results are used as the basis for the private company's certification. In other instances, private company inspectors actually perform the inspection. Settlement in most instances is based on the inspection results provided by FGIS or an FGIS delegated State agency. In rare cases, such as corn shipments to Portugal, settlement has been based on the private inspectors results or destination grades.

Setting Grades and Standards

The grades and grade factors are established by FGIS under the authority of Part 800.4 of USGSA. In the case of corn and wheat, these factors were selected in the early 1900's. Soybean grades were established in 1922 as voluntary and brought under the USGSA by a congressional amendment in 1941. There were no changes in the number of factors included until the removal of moisture from wheat in 1934 and from corn and soybeans in 1985. However, grade limits and definitions for the factors were changed frequently during the ensuing years.

The procedures for changing grades are clearly specified in the USGSA. Most proposed changes require publication in the Federal Register, solicitation of comments and in the case of the new or amended grades requires a 1 year waiting period before becoming effective (For more detailed information see Appendix A).

Changing and revising the grade factors require an understanding of the alternatives for implementing the introduction of a new test or quality factor. There are two authorities involved (USGSA and the Agricultural Marketing Act) with three options under USGSA (Figure 1).


New Test
USGSA
AMA
Official Criteria
Standard
Official Criteria
Grade Determining
Non-Grade Determining

Official criteria are provided only on request of buyer or seller. Factors in the standards are required to be reported with every official grade. Non-grade determining factors are shown on the certificate but do not have maximums or minimums associated with the numerical grades. Grade determining factors establish the numerical grade according to the lowest factor approach. The four categories are illustrated below (Table 1).

Table 1. Examples of quality measures under USGSA and AMA.

AUTHORITY	EXAMPLE FACTORS
USGSA	
Grade Determining Standards:	Foreign material Damage Test Weight
Non-Grade Standards:	Moisture
Official Criteria:	Protein in Wheat
AMA	
Official Criteria:	Aflatoxin Falling Number Pesticide Residue (EDB)

In summary, FGIS operates under two pieces of legislation: USGSA and AMA. Regulations and standards have been promulgated under each statute. Regulations implement the overall programs established by each statute. The standards only define and outline the specific factors and establish grades. Both statutes provide for testing under "other criteria".

The Food and Drug Administration (FDA) also has responsibility over grain quality issues related to health and safety. For example, pesticide residues, aflatoxin and adulteration. It was an FDA ruling that the addition of water to grain to increase its weight or value was adulteration and subject to prosecution. The separation of responsibilities between FGIS and FDA is somewhat vague in principle. For example, dust in grain is a health and safety issue but it is under

FGIS not FDA. While some might argue that all aspects of grain should be under FGIS in order to concentrate responsibility under one agency and on the grounds of efficiency, the micro analysis for residues is dramatically different from the macro analysis of test weight, for example. On the grounds of measurement technology and analytical methods there seems to be justification for maintaining the current separation of responsibilities.

EVALUATION OF U.S. GRAIN GRADES AND STANDARDS

Debate on grain grades, the complaints of foreign buyers, and the numerous proposals for regulatory and legislative changes leave one with a strong sense of deja vu. There is an uneasy feeling that many of the proposals and complaints have all been debated before. Recent complaints about "certificate final"[1], excess foreign material at destination, and spoilage and heating during transit are nearly identical to those of the late 1800's. These problems are documented repeatedly in the congressional hearings of 1908, 1928, 1975, and 1986.[2] Even the wording is almost identical despite a span of nearly 100 years.[3]

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[1] Certificate final in the export/import contract means that weight and grade are determined in the export elevator and the buyer has no legal recourse regardless of delivered quality, unless it can be proven the origin grade was incorrect at the time of loading.

[2] A complete history of the issues and legislation can be found in "Grain Grades and Standards: Historical Issues Shaping the Future," Lowell D. Hill, University of Illinois Press, manuscript under review.

[3] Senate Report 988, July 27, 1912, p.3, criticizes the current system for rewarding adulteration. "Under the present conditions an enormous system of mixing or adulteration of grain is forced on all the home markets and also the foreign market, destroying all confidence in our grades and working to the detriment of the grain trade." Seventy-four years later, Congressman Dorgan used similar phrases during the 1986 hearings. "In short, the U.S. system being what it is allows and encourages dockage to be added back into wheat shipments...unless we confront this problem, we will further erode our export potential.

A Review of History

The legislation authorizing the establishment of federal grades and standards for grain was passed in 1916 following more than 50 years of debate and repeated attempts by the grain industry, trade associations and boards of trade to establish private and regional measures of grain quality. Private firms can increase profits by individually differentiating quality from that of other firms. This self interest blocked every attempt to obtain voluntary adoption of uniform grades and standards even though the trade associations recognized that the industry in total would benefit from the uniformity. After many years of educational efforts and frustrated attempts to obtain support from the various state trade associations, the National Grain and Feed Dealers Association agreed to endorse a compromise bill for federal grades. The compromise garnered reluctant support from the opposing positions of voluntary adoption of private grades vs. full federal control of inspection and grades. The compromise allowed federal supervision of uniform standards and inspection by private firms (many already in business in 1916). That compromise eventually returned to haunt the industry when the 1975 inspection scandal among private inspection agencies raised serious questions about the integrity of U. S. export grades.

More than 150 bills and amendments have been submitted by U.S. Congressmen since Senator Paddock first proposed federal legislation in 1890 to establish measures of quality that would be uniformly and objectively applied throughout the entire nation. Despite all of this legislative activity, the Grain Standards Act of 1916 (USGSA) remained intact so far as the basic premises and procedures are concerned, until 1986. The objective of the Act, the complaints, and the quality problems have continued for over a century despite all the legislative, administrative, academic and industry efforts spent on improving quality measurement. One cannot help but ask why there appears to have been so little progress in resolving these persistent problems. There is no simple answer to that question but the obstacles to a permanent solution must be recognized if the current efforts of congress and industry are to result in an outcome anymore permanent than the many efforts that have gone before. The obstacles include:

1. The changing nature of the industry in terms of technology and genetics results in quality characteristics that change from one crop year to the next and from one part of the country to the next.
2. Industry and government have often refused to accept that problems exist. Faith in the infallibility of a market system has made it difficult to accept that government agencies have a function in setting uniform grades in order to facilitate an efficient market.
3. Most of the participants in the debate have seen themselves as adversaries since the beginning of the discussions. Each group -- farmers, processors, grain merchandisers, and government -- have spent much of their public efforts trying to place the blame on one or more of the other groups.
4. The Grain Standards Act and the regulatory agencies implementing the Act have focused on the objective "to facilitate marketing." Economic principles have not been incorporated in the grade

factors, factor limits or the many seemingly arbitrary changes.

Purposes of Grades and Standards

Since the beginning of federal regulation of grades and standards in 1916, the official purpose of grading was to provide uniform standards for promoting and protecting grain moving in interstate and foreign commerce "so that grain can be marketed in an orderly and timely manner and that trading in grain may be facilitated." It has seldom been recognized that the lack of an economic justification in that directive has been the cause of much of the difficulty in arriving at a consensus on grades, grade factors, and standardization in the grain industry. Although the early researchers such as Boerner, Shanahan, and Duvel made frequent reference to "intrinsic value" and "value in end use" these criteria were seldom in evidence in the development of grades for each grain, or in the numerous changes that were introduced in subsequent years.

Much of the disagreement over specific changes is the result of explicit or implicit disagreement over the purposes of grades. Each group held a different view. Many in industry and government viewed the USGSA as a convenience for merchandisers. Processors wanted the grades to indicate yield of processed products. Farmers wanted assurance that discounts associated with the grade factors were based on differences in real value in use. Congress often viewed the grades as a cause of foreign complaints and lost export markets. These many diverse and conflicting opinions as to the purposes of grades have complicated the search for equitable solutions. Clearly, if the grain exporters, grain processors, Congress, and farmers hold divergent views on what the grades are intended to accomplish, they cannot be expected to agree on which grade factors would meet their diverse and conflicting purposes.

The lack of clear criteria for determining grades and changes in grades leads to considerable arbitrariness in the numbers that are selected. There are numerous examples.

Ex. 1. Test weight for No.1 corn is 56 pounds per bushel. This is also the legal weight for a bushel of corn. However the test weight for No.1 soybeans is 56 pounds per bushel even though the legal weight for soybeans is 60 pounds per bushel.

Ex. 2. Until 1985, moisture was not a grade factor in wheat, was a criterion for "tough" in oats and a grade determining factor in corn, soybeans and grain sorghum.

Ex. 3. There appears to be no logical pattern in the sieve sizes used for defining foreign material or dockage in the various grains. Sieve sizes have been changed through the years with little evidence that these changes have improved the ability of grades to describe value in the market place.

The lack of clear goals, objectives and criteria inevitably led to reversals as well as inconsistencies within the grades. For example, test weight limits for grades No. 1 and No. 2 were introduced into the original corn standards in 1916; were added to grades 3, 4, and 5 in 1918; were lowered in 1934; were raised in 1959. Throughout all these changes researchers were questioning whether test weight was a relevant measure of value in any of these grades. The stated objective of "to facilitate trade" was not served by these changes. No other criteria except "the squeaky wheel" can be found to explain these and many similar seemingly arbitrary changes. Those who argue that the only purpose of grades is to describe physical and biological characteristics have been unable to find a criterion by which they could justify the characteristics chosen. For example, why measure kernel density but not kernel size? Why measure the percent of split and broken beans but not the percent of whole kernels in corn? There are many physical and biological properties of grain and without additional criteria for guidance the factors and factor limits become arbitrary numbers.

A set of clearly stated purposes of grades based on sound economic principles was absent in the legislation and administrative changes in grades between 1916 and 1986. The many changes during that period apparently did little to resolve the basic problems and issues. In 1986 a relatively simple change in the language of the USGSA opened the door to a new era in the identification of quality as a means of efficient communication of information about value.

In June of 1986, the North American Export Grain Association submitted a report emanating from a series of industry-wide workshops. This report titled "Commitment to Quality" presented a group consensus to serve as guidelines for congress and FGIS in revising grades. One of the most important pieces of that report was a new definition of the purposes of grades and standards. Those four purposes are:

1. To define uniform and accepted descriptive terms to facilitate trade.
2. To provide information to aid in determining grain storability.

3. To offer end users the best possible information from which to determine end product yield and quality.
4. To create the tools for the market to establish quality improvement incentives.

These four objectives were then incorporated in the 1986 Grain Quality Improvement Act with the passage of PL 99-641, November 10, 1986. FGIS, for the first time had a set of criteria on which to base changes in grades and to evaluate the numerous proposals for change. Each of four criteria provide a basis for evaluating current grading standards and the recent efforts by FGIS to improve measurements of quality.

To Facilitate Trade. Almost any set of factors can meet this criteria. It is important that grain be grouped into a relatively few number of categories to make buying, selling and classification efficient and inexpensive. Trade is facilitated by a small number of grades determined by a minimum number of factors. Three numerical grades in the corn standards may in fact be more desirable than five from the standpoint of simplicity of trading.

The factors in current grades are for the most part easily measured and provide a basis on which buyers and sellers can communicate price and appropriate discounts. Some of the factors have the additional advantage of being commonly used in international trade (for example, heat damage) and thereby serve to facilitate communication within the international market as well as the domestic market.

Since almost any set of factors and grade limits can be handled equally well by the grain industry as long as they are universally accepted, recent changes by FGIS have made little improvement on this criterion. In fact, any change creates some disruption and a period of adjustment which is counter productive in so far as facilitating trade.

The technology and terminology for measuring the current factors have been in use for a sufficient period of time to make the trading of grain on these factors and grades extremely efficient. Domestic and international contracts have been written using this terminology for many years. Trading in the market place is readily handled with a minimum of specification. These terms are adequate for basic contracts and quotes in the future's market as well as in international trade. Millions of bushels change ownership with a simple phone call basing price on the numerical grade. In general, measurement technology provides consistent, repeatable grading results at each point in the market channel.

To Aid in Determining Grain Storability. The factors that influence storability of grain have been well documented by many scientists dating as far back as the early 1900's with the grain storage studies done by Dr. Duvel, USDA. These factors are moisture, temperature, air flow, mold and insect infestation. The more technical attributes of these characteristics are covered elsewhere in this report. The length of time in which the grain has been held in storage and the condition under which it has been stored is also an important criteria.

Current grading standards provide little information on direct measures of storability. Moisture content is provided in terms of averages but it has been demonstrated that the range of moisture among individual kernels may be more important than the average. The grades identify damage but this is an arbitrary determination of a stage of mold development and storage deterioration that does not provide information on how much longer the grain may be stored before it goes out of condition. The total damage factor does not show how far deterioration has progressed or the rate of deterioration until the kernels show enough damage to alter the grade. Numerical grades alone certainly provide no information on storability and the factors of foreign material and fines, test weight, damage, and average moisture are indirect indicators at best.

Changes in grading practices and grade standards have done little to improve measurement of storability since the 1920's when Dr. Duvel suggested acidity as a measure of storage life and an indication of mixtures of old and new crop grain. The 1986 changes in the interpretive line slides determining damage for soybeans did not improve the ability of the grades to predict storability. The correlation between damaged kernels and levels of free fatty acid was used to demonstrate the increased ability of grades to indicate oil quality; the relationship with storage was not demonstrated by FGIS.

Most of the measures for storage life at the present time are based on laboratory procedures. No commercial test is available to provide a quick indication of stage of deterioration of a lot of grain or the time remaining before it will go out of condition.

To Measure Value in Processing Products. Because most grains are used for more than one purpose, it is not a simple matter to identify those characteristics that influence value, however, some are quite obvious such as oil and protein content of soybeans. The nutritional composition of corn, the starch content and recovery rate, and the baking characteristics of wheat, are all end use properties that are desired by processors. However, few of these can be converted directly to measures of physical or chemical properties of the raw grain. Research in recent years has identified some factors that relate to value that can be measured in the commercial market channel. For example, hard endosperm corn provides a higher yield of flaking grits. Obviously high oil and high protein soybeans provide higher yields of oil and soybean meal. Breakage susceptibility tests identify the ability of corn to withstand handling without increasing breakage. Several tests are available that indicate baking and milling characteristics of wheat and are frequently used in laboratories in U.S. and Europe -- for example falling number, Farina graph, hardness and baking tests. However, there is not complete agreement within the industry that these attributes are always a clear indicator of value.

Current grades do a very poor job of meeting the criterion of end use value. Soybean grades include little indication of the oil and protein content. New varieties of wheat have diminished the effectiveness of class and grade in evaluating flour and baking characteristics of wheat. Numerical grade on corn is often unrelated to its feeding value or yield of starch. In general, those characteristics of the raw grain most closely associated with value of [illegible] products derived are not currently in numerical grades. Purity and cleanliness in terms of percent of foreign material, or percent of other grains provides one of the few indications of value in the current standards. However, even here, there is lack of clarity; the term "foreign material" means different things in each grain, and the term "broken corn and foreign material" (BCFM) does not differentiate between broken corn and impurities despite the difference in value.

FGIS activities of the last few years have moved toward improving the measurement of end use value. For example, even the simple step of rounding dockage percentage to the nearest one-tenth gives a better indication of the amount of grain versus non grain that is being purchased. When compared to the previous method of rounding down to the nearest half percent the change better reflects true value. FGIS has also taken steps to differentiate more critically on damage in soybeans. The change in the interpretive line slides has been linked to the level of free fatty acid which is in turn a direct measure of the quality of the oil derived from the beans. Progress is therefore being made towards finding better measures of value.

Additional measures are available that have not been incorporated into grades or standards. There is a lack of total industry agreement that these measures are sufficiently accurate and reliable to be introduced into grades. Continued commercialization of measures of breakage susceptibility in corn and soybeans, chemical properties of corn, soybeans and wheat, new measures of baking properties and classification of mixed varieties of wheat, and rapid measures of oil and protein in soybeans are all candidates for incorporation into the standards or at least to be made available as information.

To Provide Market Incentives. Measurement of grade or quality factors that result in price differentials in the market provide an incentive for each point in the market channel to make decisions to improve the quality and avoid the discounts. This incentive works back through the market channel to producers who may change harvesting, drying and storing practices, or may select different varieties. Preference for varieties with certain quality characteristics will in turn be reflected to plant breeders and generate better varieties in the future. In a competitive market, profit is a strong driving force in the decisions of firms, whether they be exporters, river elevators, producers, or plant breeders. While the market itself sets the incentives in terms of prices and price differentials, the grades are not neutral in this scenario. For example, there is an incentive for farmers to select varieties of corn that will weigh at least 54 pounds per bushel in order to avoid discounts in the market. This incentive to the producer has been translated into incentives for the plant breeders who have spent significant research funds to develop varieties that will produce a high test weight corn under normal conditions. Test weight for No. 1 corn was an arbitrary number established in 1916 and has been changed at least three times since the grade standards were first introduced. The incentives for test weight above 54 pounds per bushel are the result of a combination of the limit set on a grade factor and a market response.

Current grades provide incentives in several ways. For example, No. 2 corn allowing 3% BCFM in conjunction with the market practice of paying top price for No. 2 corn, gives farmers an incentive to incorporate 3% BCFM in their deliveries. By the same token, elevators have an incentive to clean or blend in such a way as to deliver 3% BCFM throughout the market channel. Any shipment containing less than 3% BCFM is a lost profit opportunity. Shipments containing more than 3% BCFM will usually receive a discount. The step functions between the grades are automatic incentives for blending, even in the case of soybeans where the base price is for No. 1 beans. Total damage of 2.0% of total weight is allowed by virtue of the limit established for No. 1 soybeans. The incentive for blending is the opportunity to sell badly damaged, low value beans for the price of No. 1 beans so long as they are incorporated at less than the 2.0% rate. The wider the range between grades, the greater the number of factors, and the greater the number of grades, the greater is the incentive for blending.

The reverse of the coin is the lack of incentive for improving quality on those characteristics omitted from the standards. With no price differential for soybeans with high oil and protein, farmers have no incentive to select varieties that will represent greater value to the processor. Yield becomes the primary and in most cases the only criterion on which to select the variety to be planted. A second example is the drying temperature of corn. Although most corn processors object to the use of high temperatures during drying, the market does not differentiate between corn dried at high temperatures and corn dried at low temperatures. The premiums paid by a few dry millers for low temperature dried corn indicate that farmers do respond to these incentives when they are offered. At the present time the incentives are not offered by means of the grades, but by means of contracts in localized areas. It is especially difficult for buyers who are some distance from the production point to obtain the qualities they desire when those qualities are not incorporated in uniform standards, grades, and terminology.

Recent FGIS efforts have had limited effect upon the incentives within the market channel. The removal of moisture as a grading factor reduced the number of factors on which blending was required by the grades, but the market still generates income from blending wet and dry corn. The change in rounding procedures for percent dockage in wheat removed the incentive to blend dockage just below the next higher break point. However, the number of grades and the steps between grades have not been significantly altered and incentives and disincentives still fall short of the ideal.

Measurement and sampling technology or testing is a problem in terms of incentives only so far as the accuracy of the equipment will not accommodate a finer distinction between qualities on certain characteristics. Increased accuracy will permit narrowing the spread between numerical grades, thereby reducing the incentives for blending.

Integrating the four purposes of grades

Changes in the grades, the factors, or the factor limits should meet the four purposes of grades. However, not all alternatives will contribute to all four purposes and it is likely that conflict between the purposes can develop. For example, complex and lengthy tests for measuring value in use will slow the inspection process, increase marketing costs and thereby detract from the purpose "to facilitate trade." As a second example, incentives are best created by a continuous discount schedule on each factor starting from zero. But a zero base requires each buyer to specify factor levels in the contract. Numerous contract specifications increase the number of segregated lots and reduces the interchangeability of vessels and sub-lots. Increasing the amount of information available to users increases the difficulty of merchandising uniform lots.

The "perfect grade" that optimizes all four purposes of grades may not exist. The final solution will be a compromise among some of the purposes (e.g., sacrificing complete information for all users in order to facilitate orderly efficient marketing) and among the various buyers and sellers who use the grades. An evaluation of the alternatives to the current system of grades and standards in the United States, illustrates some of the trade-offs that are inevitable in setting grades and standards.

Alternatives to the Present System

The current system of grades used in U.S. domestic and foreign trade is generally known as "numerical grades determined by the lowest factor." In export trade most contracts specify that the grade determined at origin is the legal basis for any dispute or arbitration regarding quality and weight. The "certificate final" system which was in use prior to the USGSA, provides advantages in terms of efficiency and costs. There are other alternatives currently in use in other countries and there are variations of our official system being used even in the domestic market. It is important to understand the basics of each of these alternatives in developing policy for directing future quality regulations.

Lowest Factor. The "lowest factor" approach to grading requires that the grade be set by that factor representing the lowest quality. For example, if test weight of corn is 53 pounds per bushel, that sample is graded No. 3 even though all other factors are equal to No. 1 or better. This method has the advantage of simplicity and is used by many of the major grain exporting countries. However, it does not always reflect true value in use since it fails to consider those factors that are above the minimum. Considerable variation in quality can occur without a change in grade. The lowest factor system also encourages blending to bring all factors down to the quality of the lowest factor determining the grade and therefore does not generate incentives for quality improvement.

Total Defects. Under the lowest factor approach all factors can be at the maximum limit for the determination of a particular grade. For example, No. 1 corn can have 56 pounds test weight, 3% BCFM, 4% damage, and 0.2% heat damage, and be called No. 2. This provides the opportunity for a shipper to blend on one or more factors to achieve the maximum allowable limit within that grade. A system of total defects would put one more limiting factor which would sum the defects in that grade across all the factors and place a maximum that would be more restrictive. Thus the accumulated value of the defects would become more restrictive than the individual factors. In the example just given, the defects are BCFM, total damage, and heat damage. Under the total defect system, a maximum value of 6% might be established, for example, and the corn would not be considered No. 2 if the sum of damage, heat damage, and BCFM exceeded 6%. Currently, U.S. grades for wheat include a factor of "total defects" with a maximum limit of 3% for No. 1. If shrunken and broken kernels are at the maximum No. 1 limit of 3%, all other defects would have to be at 0. The total defects can be very restrictive. This approach provides additional information about quality and an incentive to increase quality since the "total defects" is more restrictive.

The total defect approach differs from the lowest factor only by accumulating the sum of individual factors. It would be more restrictive than current grading but this restriction also could be achieved by changing grade limits on the present grade factors. Total defects also contains a logical inconsistency. It establishes limits on three factors for No. 2 wheat but if the sample meets all these criteria, it will be classed as No. 3 on the basis of total defects.

Absence of Imperfections. An alternative to "total defects" is "total perfect kernels." This approach also sums the percent of defects, imperfections, or impurities and subtracts the total from 100 to obtain the percent of perfect kernels. Each grade has a minimum limit on percent of perfect kernels. Corn grades in China are based on this system. U.S. grades for oats include a factor of "sound oats." This system differs little from the "total defects" concept except that it reports absence of defects rather than presence of defects.

Weighted Factor. The weighted factor approach in grading would include a set of grade factors and factor limits but each factor would exert a different effect in terms of grade determination. This is in contrast to the lowest factor approach where the grade is lowered if any one factor exceeded the limit. All factors are equally important. In the weighted factor approach, defects would be divided into major and minor defects and each assigned a weight to be multiplied times the percent of that defect present. The total sum of the defects times the weighting factor would determine the grade. Grade would be influenced by the number of factors that were below grade, the distance each of those factors fell below the grade limit, and the relative seriousness of the defect. This system would incorporate more information in the numerical grade and allow finer distinction among the combinations of factors. Its disadvantage is its complexity, the arbitrariness of the weighting factor assigned to each defect and the lack of clear criteria on which to set the break points between grades. In order for the numerical grade to indicate value in use, the weighting factors would have to differ among uses. The complexity of such a system would probably eliminate this alternative on the criteria of the 1st purpose of grades which is "to facilitate trade."

Contract Specifications. The issue of whether grades are required or whether each buyer may simply specify terms in [illegible] contract has been debated since the idea of numerical grades was first presented to merchandisers in the late 1800's. So long as contracts are legally enforced, buyers and sellers may agree to any set of factors, characteristics and conditions of shipment which they desire. In fact many contracts contain pages of these types of specifications in addition to the grade. The advantage of grades over contract specifications is that they facilitate communication. When the size of the grain trade became too large for buyers and sellers to physically and simultaneously view the lot being sold, terminology was required that would permit description by factors. The numerical grade was chosen as a way of describing several factors in one number. Each buyer could identify the characteristics and factor limits that best meet the conditions in his plant. However, if his needs are unique, resale in the market becomes difficult and segregation is required for each buyer's specifications. The efficiency of the current marketing system for grain relies heavily on uniformity for the majority of the crop being marketed.

Although most foreign buyers now use numerical grades for purchasing corn, soybeans and wheat, they almost always include additional factors besides the numerical grade. Numerical grade alone seldom conveys sufficient information to satisfy the buyer's needs. Other factors are therefore specified on the contract. It is a small step to go to an entire factor basis and eliminate numerical grades. The primary disadvantages are a) a much wider range of quality characteristics between vessels and [illegible] difficulty in resale if other buyers do not want the same specifications; b) increased difficulty in segregation within the export house and blending to a wider range of specifications; and c) increased complexity in writing the contracts. None of these disadvantages are insurmountable. The problem of reselling uniform lots has become of much less importance in recent years. The number of times a vessel is resold after leaving port has been reduced in number from what was happening during the 1970's. The complexity of identification is not insurmountable since most buyers are already specifying grade plus 2 or 3 factors; they would be specifying only 1 or 2 more. There would be more problems of keeping qualities segregated throughout the market channel and lack of uniformity throughout the market channel if there were no numerical grades.

One of the purposes for blending is to achieve a uniform product. The first purpose of grades and standards is to facilitate merchandising. This purpose is not accommodated by a system where every buyer develops his own set of quality factors, his own definitions and his own factor limits. The complexity and the inefficiencies of such a market would result in a major reduction in welfare for both buyers and sellers throughout the market chain. Grades, therefore, become a means of creating uniformity of quality in the market channel. They are most useful if they reflect the needs of the majority of the buyers in the market so that additional contract quality specifications are the exception rather than the rule.

Fair Average Quality (FAQ). The contract for fair average quality specifies that the grain shall be equal to the average quality of grain exported or imported at a specific location. The most common FAQ contract in previous years has been the GAFTA (Grain and Feed Trade Association) of London which specifies that quality delivered will be equal to the average of the quality from that country of export to that country of import for the month in which the delivery was made. Samples are taken from each vessel and stored by GAFTA in their London laboratories. A composite sample at the end of each month is created as the standard and any shipper who thinks that the quality of their shipment did not meet FAQ, submits their samples to be judged against the GAFTA standard. Arbitration decisions are based primarily on visual inspection by an arbitration committee. Most GAFTA FAQ contracts are based on delivered quality. The standard varies between months, countries of origin, and crop years. The quality characteristics are few in number and consist primarily of visual observation.

The advantage of FAQ is its simplicity and its flexibility to adapt to changing crop years. This advantage to the seller is, of course, a disadvantage to the buyer. The contract does not cover all of the factors on which buyers might like information, and the floating standard leaves the buyer uncertain as to what quality he may receive for processing. It is often a destination contract (advantage to buyers, disadvantage to sellers) and covers factors not likely to change in transit. Since half the vessels are mathematically below the FAQ standard, it is conceivable that many contracts would require court arbitration. In fact, the system is manageable because the FAQ factors and sampling methods are not sufficiently specific to support arbitration action except in cases of extreme deviation from the FAQ standard.

The FAQ system provides no incentive for quality improvement since it purports only to describe whatever quality is produced. The extent to which the FAQ system describes value to users depends on the factors included. In the case of the GAFTA corn contracts the factors describe primarily condition, rather than intrinsic value characteristics. Some of the soybean contracts include oil and protein. The simplicity of FAQ facilitates trade but the potential for disputes and arbitration can reduce marketing efficiency.

Variations on the FAQ system include contracts which specify origin instead of destination. Canada and Australia have sometimes generated a fair average quality based on harvested quality for that crop. The FAQ standard is usually established with respect to selected characteristics of special importance.

In recent years the FAQ contract has become less frequently used. Argentina, South Africa, and Brazil all report exporting primarily on numerical grades. However, European buyers have reported continued use of destination FAQ on soybeans.

Destination Grades vs. Certificate Final. Most U.S. contracts specify weights and grades final at origin. This means that the grade certificate issued immediately after the vessel is loaded is the final document on weight and quality and the buyer has no recourse beyond proving incorrect grading [illegible] origin samples. Foreign buyers must prove that the vessels were improperly loaded or graded at origin before they can claim restitution for quality. Grain received in poor condition, badly broken, spoiled, sprouted, or insect infested, is not sufficient evidence on which to base claims for damage because the contract specifies origin certificate final.

The alternative to certificate final is destination grades (often in conjunction with a C.I.F. sale). In this case, the seller guarantees delivery to the foreign port and guarantees quality at that destination. This alternative has often been suggested by congressmen and others as a solution to the problem of foreign complaints. However, it is important to evaluate this alternative more carefully. There are many unanswered questions in the desire to guarantee destination quality. For example, who will take the destination samples and how? If the samples are taken after the vessel has been unloaded, then most of the breakage and damage about which foreign processors complain would have been done by the unloading device, not by the shipper. Another question: what type of guarantee can the shipper make for a vessel that will be distributed among 10, 20 or even 50 different buyers, each one getting only a small portion, and often a segregated portion, from a vessel with a highly variable quality among sublots? A third question: since the buyer specifies the quality characteristics and frequently requests moisture content unsafe for long voyages through warm water, how can the shipper guarantee quality at destination if he does not also control the quality which the buyer is allowed to purchase?

The buyer has always had the alternative of using a contract that specified destination quality. Few shippers are willing to take that type of risk at a price that the buyer would be willing to pay. With no control over unloading or sampling, the shipper is in a poor position to guarantee destination quality and the number of contracts taken into arbitration court would undoubtedly rise dramatically resulting in a significant increase in cost and delays in settlement.

Certificate final is a highly efficient marketing technique, and enables minimum cost quality guarantees up to the point where the exporter transfers responsibility for quality to the captain of the vessel or to the importer. It has the disadvantage of customer dissatisfaction with the delivered quality and their inability to control quality when several handlers stand between shipper and user. It also enables the shipper to load close to the quality limits without regard to the inevitable consequences of placing that quality in the vessel.

Origin and destination contracts can be used to guarantee quality under any set of grades and standards. However, there are differences in incentives between the two systems regardless of the factors used. Destination guarantees place additional responsibility and thus economic incentives, on the exporter to load grain that will maintain quality during transit as well as meeting the contract at the time of loading. This alters the loading strategy. For example under origin grades, a 14.0 percent moisture contract can be met with a blend of 8 and 16 percent moisture soybeans. Under destination quality guarantees, this blending would not be a good strategy under most time and temperature conditions. The high moisture beans would probably result in damage levels at destination exceeding the contract limit.

Destination quality contracts place additional responsibility on the exporter and create different incentives that influence the process by which the contract grade is achieved.

The issue of origin and destination grades must also be discussed in the context of domestic markets as well as the export market. The same issues exist in both markets but the results are different for two reasons: (1) the time between origin and destination is usually much shorter in the domestic market and (2) sampling and grading procedures at origin and destination are subject to a single set of official regulations in the domestic market: FGIS has no control over sampling and grading at foreign destinations.

Domestic contracts specify origin vs. destination grades as well as official vs. private inspection results. Confidence in accuracy is developed with a large number of transactions over a period of time and by the option of calling for official grades and an appeal if needed. This confidence often results in acceptance of origin unofficial grading where direct contact between buyer and seller has generated mutual trust. Trade rules and arbitration procedures established by the National Grain and Feed Association also provide an important alternative and supplement for domestic trade.

Dual grades. A dual grading system could be based on a separation of domestic and foreign markets or on a separation of use. A separate export grade has often been suggested as a way to compete in international trade with more restrictive quality specifications. The Canadian system establishes separate grade requirements for export wheat and controls purchases, movement, and cleaning procedures between country elevators and the ports to administer this grade. Separate food grades and feed grades have also been suggested for corn and wheat. Food grades would be more restrictive especially with respect to purity, and could include more information on value in processing.

Separate grades for different users could provide more information on value. The food grade or export grade could have price differentials that would generate market incentives for improved quality. The market would direct the higher qualities into the higher valued uses. The dual grading system would create a more complex marketing system and would probably increase the cost of segregation and transport. Probably the greatest difficulty would be determination of which grade and discount to apply to the producer. Since ultimate use would not be determined at the time of farmer delivery and, in fact, intended use might be changed more than once in the market channel, the higher discounts on food grade or export grade would have to be applied against the producer. This would generate incentives for quality improvement on all grain at a cost that would not be justified for feed use in domestic markets. The dual grades would not facilitate an efficient market.

APPLYING ECONOMIC CRITERIA TO CHOICE OF FACTORS AND STRUCTURE OF GRADES

The four purposes of grades do not lead directly to a system of grades and standards. An intermediate set of guidelines is required.

1. To define uniform and accepted descriptive terms to facilitate trade.

   This requires a small number of categories established by clearly defined factors. The factors must be readily measured in commercial trade, objectively determined by technology that gives repeatable results at each point in the market channel. The grades and factors must be acceptable to, and used by, most participants in the market. Trade is also facilitated by stability and absence of change in the grades since any change results in uncertainty and adjustment.

2. To provide information to aid in determining grain storability.

   This purpose would be met by tests that reflect storage history as well as predicting remaining storage life before loss of value in use. Information on infestation by molds, fungi, and insects needs to be accompanied by the extent of the development and deterioration. Kind of infestation is also an important measure of storability as a guide to actions required to inhibit further deterioration.

3. **To offer end users the best possible information from which to determine end product yield and quality.**

The characteristics of raw grain that indicate the quality and quantity of processed products differ with different industries. Factors selected for inclusion in grades should either be common to several industries or be important to an industry consuming a significant portion of the crop. The more directly the factor measures the desired end product, the more efficiently will the grades reflect value.

4. **To create the tools for the market to establish incentives for quality improvement.**

Incentives in grades are created in part by including factors that are economically important. To provide the market the maximum opportunity to establish price incentives the grades should: (a) minimize the distance between factor limits for each grade; (b) report all values as accurately as measurement technology allows, using standard mathematical procedures for rounding to the nearest significant digit; (c) convey important economic information to producers enabling them to respond to producer preferences related [illegible] to value.

The economic criteria developed for each of the four purposes of grades provide guidelines in the grades and selecting grade, factors, and factor limits.

Choosing the Factors to Include in the Grades

The choice of which factors shall be grade determining requires an examination of the second and third purposes of grades established by the 1986 Grain Quality Improvement Act. Each factor included must meet the same tests: (a) does it provide information on storage? (b) does it provide information indicating value to the end user? The factors related to value may change as research identifies new or improved measures of value. Many of these are already known but are not part of grades or standards. For example, impurities, oil and protein are factors generally accepted as measuring value in whole soybeans, yet they are not part of grades and standards.

Grades, Standards and Official Criteria

The factors selected as indicators of value may be included in the grades, in the standards, or in official criteria. Grade factors determine numerical grade according to the factor limits established. Factors in the standards do not determine grade but must be included on the certificate as information whenever an official inspection is made. Official criteria are measured and reported on the certificate only when requested.

Assigning each factor to one of the three categories requires a guideline that can be objectively employed. It has been previously established that grades should [illegible] the needs of a majority of users and they should reflect value for those uses. This suggests that grade factors are those factors relating to cleanliness, purity, and soundness (absence of imperfections). Using this guideline the grades would include factors such as impurities, fines, total damage and heat damage. The lower the values of any of these defects, the greater is the value. Nongrade factors are those related to intrinsic properties such as broken kernels, moisture, oil and protein content, and other chemical characteristics or physical properties that influence value for major processing uses. Higher or lower percentages on these factors do not necessarily mean higher value in use over the entire range. For example, the best level of protein in wheat depends on the ultimate product to be made from the flour. Lower moisture content means more dry matter per pound, but 5 percent moisture corn is not generally of greater value than 12 percent because of the effects of overdrying. There is usually some optimum value for each of the factors in the standards but this optimum varies with the use and location in the market channel.

Under Section 4 of the Grade Standards Act, factors in the standards must be measured whenever official inspection is performed. Factors considered as official criteria are measured on request. One may debate the advisability of that particular part of the law [illegible] its present form it leads to the conclusion that those characteristics of most importance to the largest number of users would be incorporated as standards. Those of lesser importance, or of importance to only a few users would be official criteria available upon request to those buyers who need them. For example, moisture and basic chemical properties such as protein, oil and starch in wheat, soybeans and corn might be incorporated as standards. Breakage susceptibility and kernel hardness in corn, kernel size in beans, and test weight in wheat are examples of factors appropriate to be made available as official criteria. These would change over time. The advantage of putting the major factors in as standards rather than official criteria is that it would move the characteristics into the market channel much more readily. Obligatory measurement throughout the market would spread the cost across the entire industry. The cost per unit would be insignificant and therefore the information would be readily available as an incentive. A characteristic that must be specified by a separate request from each individual buyer would increase the cost of information. For example, the true value of information on test weight is irrelevant under the present grades since everyone is required to measure test weight. The marginal cost to the buyer for that information is nearly zero. In contrast, if only one buyer specifies oil content in his soybean contract the cost of information would be much greater because the cost of measurement for oil throughout the market channel would be borne by the single buyer and would be spread over only those bushels which he purchased.

Objective criterion based on the 4 purposes of grades has provided a basis for choosing factors and for dividing these factors between grades, standards, and official criteria. This leads to the next question of what grade limits should be set on each factor to separate numerical grades.

Setting the Grade Limits on Each Factor

It was previously discussed that the base value on the various factors was an automatic incentive throughout the market channel to add materials or to blend to reach that base limit. Blending the damaged beans with good beans does not increase the value of the damaged beans, but it does increase the price of those damaged beans for they may now be sold as No. 1. The criterion of incentives for improving quality dictates that the base be set at zero. The argument that zero is unobtainable or that farmers may be unable to deliver perfection is irrelevant if we accept the four purposes of creating standards. Those four purposes do not include "minimizing farmers' discounts" or "describing the average quality delivered by good farmers." The objective of a grade is "to describe the value of the lot of grain being sold." If the percent of damaged kernels can change from 5.0 to 6.9 percent without changing grade, then numerical grade does not provide complete information on differences in value. Current grades for soybeans allow 1.0 percent foreign material with no discount; implying that any level between 0 and 1.0 percent represents equal value. The first 0.5% of foreign material in a load of soybeans has no more real value than the third 0.5% of foreign material even though the third is discounted and the first is not. Tighter limits on existing grade factors would reduce the incentives for blending and provide a more accurate measure of value. However, it is as difficult to justify an arbitrary limit of 0.5% as it is to justify an arbitrary limit of 1.0%. The only objective limit is zero with discounts for any additional levels within the ability of sampling technology to differentiate.

The base for the nongrade factors is of course immaterial since it is not grade determining and the market is now free to choose what, if any, price adjustment is to be made for different levels of those factors.

The zero base concept is limited by the freedom of the market to respond. Unless (or until) export contracts and prices are established at zero base, merchandisers could start discounts at any level they desired, including the current factor levels for No. 2 corn and No. 1 wheat and soybeans.

Number of Grades

The final question in setting grades is the number of different grades required. The number of numerical grades differs among grains -- malting barley has 3; soybeans and sorghum have 4; corn and wheat have 5. Historical records provide no rationale for these numbers. The market seldom uses but one of the numerical grades. The justification for the different numbers is not clear. The fewer the numerical grades, the simpler is the marketing and the less is the space required to segregate the grades in storage and transport.

Few markets quote prices for No. 1, No. 2, and No. 3 corn, soybeans, or wheat. In nearly all cases, a base price is given on one grade and discounts or premiums attached to deviations on each factor from that base. For example, at the [illegible] elevator level, nearly all corn is purchased on a No. 2 base and farmers' prices are established by discounting each factor that falls outside of the No.2 limits. International markets generally specify No.2 soybeans or No. 3 corn and prices in the contract are usually quoted for one grade with adjustments for deviations. A single grade for each grain would eliminate incentives for blending other than to meet the quality characteristics desired by the buyer. In addition, it would force the foreign buyer to specify the quality characteristics and the level of those characteristics that he wishes. He would no longer receive 4% BCFM by default when ordering No. 3 corn. He would be forced to specify the level of foreign material desired and would know in advance, the trade-off with price.

The market seldom uses more than two grades. More grades increase the complexity for the market and provide no increase in information. The disadvantage of a single grade is that nearly every buyer must use one grade or specify levels on each factor. This would result in increased diversity of contracts, less opportunity to resell uniform lots, and increased transaction costs. The final number of grades to be established for each grain must be a compromise between the purposes of incentives, identifying value, and facilitating market transactions.

Evaluation of Recent Legislation

Several legislative proposals have been aimed at changing U.S. grades and the methods of measuring quality. The principles in the preceding pages established the criteria for evaluating these proposals as well as the 1986 Grain Quality Improvement Act.

Optimal Grade

The concept of an optimal grade proposed a single grade with low values for selected defects and discounts on any defects above the base. The objective of the concept was to reduce the incentives built into the current standards for blending and thereby better meet the fourth purpose of grades. It used the principle of grade factors being required to reflect cleanliness, soundness and purity. It set levels for that grade at low levels but not at zero. It would have met the criterion of simplicity, facilitating trade, and removing incentives for blending. However, it did not meet the criterion for measuring quality for various uses. Its greatest deficiency was a failure to identify the nongrade factors that would be incorporated in the standards. It also failed to eliminate completely the blending incentive by not setting the base values at zero. Rejection of the optimum grade was probably more a reflection of problems of implementation than of failure to meet the criteria established by the purposes of grades.

Evaluation of the Grain Quality Act of 1986

Perhaps the most important contribution of this legislation was introducing into the Grain Standards Act the four explicit purposes of grades including three relating to economic value. Without these objectives, the regulations pertaining to grain standards and grades had primarily reflected response to pressure from various groups. Without support from one or more major associations or organizations, it was extremely difficult to make any changes in the grade standards because the only criterion was that of facilitating trade. With the four purposes included in the USGSA, FGIS has criteria on which to base changes and can justify those changes in terms of what is best for the industry. Grades should never be developed or proposals evaluated on the basis of the extent of support or opposition by individual firms. Grades, by their very nature, are inconsistent with the goals of individual firms to differentiate their product. Grades should be based on economic and scientific principles of aggregate welfare -- they are not a popularity contest to be determined by a majority vote.

Prohibitions vs. Market Incentives

There are two basic choices in developing solutions to the problems and issues raised in grain grades: 1) legislative prohibitions against practices that are detrimental to quality; and 2) changes in the economic incentives of grades in pricing practices to allow the market to discipline the offenders. The first alternative is focused on controlling the process by which grain is marketed; the second is focused on accurately evaluating the product and the value of different qualities.

Throughout the history of grades there have been numerous bills and amendments intended to legislate specifics in the grain grades. Nearly all legislative attempts to change specifics in the grades have failed. The successful legislative activities since the late 1800's have focused on setting policy and creating a framework for administrators to implement rather than legislating specifics in the grain grades. During the 1980's numerous bills or amendments have been submitted to place restrictions on the way in which foreign material, dockage or dust can be handled, particularly in the export markets. The 1986 Grain Quality Improvement Act included a prohibition against reintroducing dust or foreign material into the grain stream once it has been removed. The intent was clear: to improve the quality of the grain being exported and especially to improve the image of U.S. grain in international markets. The success of this type of legislation is yet to be determined. However, there are several difficulties in implementing prohibitions while leaving intact the grade structure that generated the incentives for blending.

The prohibition in the 1986 Grain Quality Improvement Act focuses on controlling the process rather than the product. Consequently, its enforcement has presented numerous difficulties; not the least of which is a definition of what constitutes foreign material. This may not be obvious until one recognizes that foreign material in the grade standards is defined in many different ways and identified with many different names. For example, in [illegible] there is [illegible] factor which encompasses all non-grain material. That factor is BCFM (broken corn and foreign material) which is defined as any material passing through the 12/64-inch sieve plus non-corn material remaining on top. Wheat includes a factor for foreign material and one for broken and shrunken kernels as well as a category called dockage. Barley standards contain three factors: dockage, foreign material, and broken kernels. In nearly all cases, foreign material is defined in conjunction with particle size, meaning materials that go through a certain size sieve. This sieve size varies among grains. In almost all cases, not all foreign material is actually removed and in almost all cases the foreign material contains small particles of the grain in question which is not "foreign" at all. Which of these definitions did Congress intend to prohibit being reintroduced into the grain?

Aside from the definition problem, the prohibition approach to controlling quality faces other difficulties. The quantity of foreign material or broken kernels incorporated into a shipment of grain -- domestic or foreign -- is controlled by the contract in conjunction with the grade limit. Therefore, the prohibition does not prevent leaving dirt, dust and foreign material in the corn and soybeans nor does it prevent blending of different lots of grain containing various levels of foreign material to achieve the maximum allowed. It only limits the procedure by which the maximum may be achieved. In addition, most of the "foreign material" in overseas processing plants is broken grain created during unloading of vessels. Consequently, it is unlikely that the actual amount of "foreign material" delivered to the foreign buyer will change but it may be more expensive to attain the contract levels at the export elevator.

The basic problem, of course, is one of trying to legislate restrictions to counter the economic incentives built into the standards themselves. By having an allowance of 4 percent foreign material in No. 3 corn, there is an automatic incentive built in to add that much foreign material to the load. Removing the incentive would generate the desired results much more efficiently than a prohibition. There is no better enforcer and disciplinarian than market prices. If we can design a set of grades that create incentives to achieve the desired end product in terms of quality the legislative prohibition would become unnecessary.

SUMMARY

Grades and standards for grain have been developed within the context of the USGSA. A continual review of these grades since their inception in 1916 has generated numerous changes and proposals for change in factors and factor limits. These have not resolved the problems or foreign complaints related to quality.

The limitations to our current grades can be summarized as follows:

1. They create incentives for practices not consistent with good management and efficiency.
2. They fail to identify many of the characteristics related to value in use.
3. They fail to reward producers and handlers for improved drying, harvesting, handling and variety selection.
4. Grade limitations on many factors are arbitrary, do not always reflect real differences in value and in some cases, are not consistent with statistical principles.

Grades and standards of other countries also fall short of the purposes of grades established in the 1986 Grain Quality Improvement Act. Future changes by FGIS and Congress should be based on movement toward an "ideal" based on the four purposes. Adoption of grades from other countries cannot provide any advantage in world markets--at best it can only help us to meet the competition not beat the competition.

The many regulatory and legislative changes in grades and standards have failed to move the industry in a consistent direction.

In fact there have been numerous reversals of previous changes. What has been lacking is a clearly defined goal toward which the system is being moved. With the four purposes of grades now established by legislation it is possible to develop a set of "ideal" grades for each grain. This ideal will probably not be adopted intact or instantaneously but it can provide a direction for future changes and a yardstick against which to evaluate alternatives. If each change adopted moves the operational grades closer to the ideal then repeated reversals should no longer create unnecessary adjustment costs and confusion in domestic and foreign markets.

Where conflicts between purposes exist they can be explicitly identified and the trade-offs and economic consequences calculated and recorded as guidance for a long range consistent policy.

The ideal grading system will include grade factors, standards for non-grade factors and definition and measurement technology for official criteria.

Grade factors

Existing research is generally adequate to identify grade factors: impurities, damage that reduces yield and quality of processed products or value in use, and fines including dust. For No. 1 grade these factor limits should be set as close to zero as measurement technology will allow. Any value above zero violates the third and fourth purposes of grades. The exact definition of these factors including sieve size for fines still requires additional research to evaluate the alternatives against the criterion of accurately reflecting value.

Standards

Those factors included in the standards should measure value for a majority of users. The preferred level may differ among uses. For example splits in beans reduces oil quality only in proportion to the time in storage. Thus domestic processors buying for immediate use may allow high levels of splits with no discounts. Foreign buyers whose processing of the beans may lag harvest by 12 to 18 months may place much more restrictive limits and discounts on splits.

Many of the chemical and physical properties that influence the quantity and quality of products derived from the grain have not been identified. More research may add to the list of properties to be included in the standards. The criteria for inclusion should be that the cost of obtaining the information is less than the value of that information to users who need the information. By starting with the major products generated from each grain, a list of physical and chemical properties can be developed that are correlated with value in use. Technology for measurement is also a requirement prior to inclusion.

Official Criteria

The list of official criteria is almost unlimited except by measurement technology. Any properties that can be accurately measured, can be requested by buyers and sellers. These would be developed only after sufficient evidence of sufficient demand to cover the cost. Information on the factors of interest for the various users could be provided by private laboratories and would be added to official criteria only if there is sufficient demand by domestic or foreign buyers to justify including them on official certificates.

Grades and standards must be designed to reward positive actions such as genetic improvement, and sound harvesting, drying and marketing practices. They must also be designed to provide the best information available on value of each shipment by descriptive terminology. All changes must be evaluated against the criterion of providing information that is worth the cost of obtaining it. Optimum information, not maximum information is the goal. Proposals for change must also be tempered with the current capabilities of the industry, the cost of adjustments vs. potential benefits, the realities of international trading rules and the historical sequence by which the industry has attained the present situation. Measurement and description of quality is only one part of the quality problem. It must be evaluated in the context of technology, competition, foreign demand and processing requirements.

Appendix A.

GRAIN INSPECTION IN THE UNITED STATES

Inspection and grading of grain is authorized and/or provided by two U. S. Department of Agricultural agencies: (1) The Federal Grain Inspection Service (FGIS) under the Grain Standards Act; and (2) The Warehouse Division, Agricultural Stabilization and Conservation Service (ASCS). In addition, regulations and standards are also promulgated under the Agricultural Marketing Act (AMA). Only FGIS is authorized to perform inspection service under AMA.

United States Grain Standards Act (USGSA)

The USGSA created in 1916, is the statutory authority under which grain standards have been developed. The declaration of policy contained in Section 2 of the USGSA states that it is congress' intent that uniform standards for promoting and protecting grain moving in interstate and foreign commerce be developed so that grain can be marketed in an orderly and timely manner and that trading in grain may be facilitated. FGIS was created in 1976 in the wake of a major investigation into illegal inspection and weighing procedures. The 1976 amendment to the USGSA gave federal inspectors additional power and required that all export grain be inspected by FGIS or FGIS delegated state agencies (Section 5, USGSA).

Standards Development. Standards for wheat, corn, barley, oats, rye, sorghum, flaxseed, soybeans, triticale, sunflower seed, and mixed grain have been promulgated by FGIS under the USGSA. Each standard consists of numerical grades, i.e. 1, 2, 3, and Sample Grade. Factors are included in each standard and maximum or minimum limits for each factor have been set for each grade. The grade for any given parcel of grain is based on the factor results determined during the course of the inspection.

Required Use of Standards. Section 6 of the USGSA states "Whenever standards relating to kind, class, quality, or condition are effective ... no person shall in any sale, offer for sale, or consignment for sale, which involves the shipment of such grain in interstate or foreign commerce ... describe such grain as being of any grade ... other than by an official grade designation." In other words, the grain standards established under the USGSA must be used whenever grain is marketed and described by grade. USGSA regulations must be followed for all inspections where the grade is designated as "U.S. No. __."

Inspection Requirements. Section 5 of the USGSA requires that inspection be performed by FGIS or an FGIS delegated State agency on all export grain for which standards have been established. This inspection takes place following the last elevation prior to loading the grain into the final carrier that will transport it from the United States. The USGSA requires that FGIS establish a national inspection system and provide domestic inspection services when requested.

However grain moving in interstate markets need not move under a USGSA grade certificate. The requirement for official inspection on interstate shipments of grain was removed with the 1968 amendment to the USGSA. The requirement that export grain be inspected by FGIS or its delegated agency was inserted in the amendment of 1976.

Official Inspection. The USGSA makes a clear distinction between "official" and "unofficial" inspection services. Official services are inspection services provided by FGIS or an FGIS delegated or designated agency. Inspection services conducted by anyone other than FGIS or these specific agencies is considered unofficial. Private companies not part of FGIS and employees of individual grain companies also provide inspection services. Official inspection in domestic markets is frequently conducted by licensed inspectors under supervision of FGIS.

Responsibility of the Federal Grain Inspection Services, USDA. FGIS operates under the authority of the USGSA and provides government regulated "third party" inspection services. The USGSA requires that FGIS develop standards and maintain a national inspection system. This inspection system is comprised of FGIS offices with Federal inspectors located at major ports, 72 designated State and private agencies located in the interior of the United States, and 8 delegated State agencies at ports not serviced by FGIS. FGIS administers field offices scattered throughout the country to oversee the activities of State and private inspection agencies.

Licensing Inspectors. All non-federal employees employed by State and private agencies authorized to perform inspection on FGIS' behalf must pass examinations on grading proficiency and be licensed. These individuals can be licensed to inspect one or more of the grains for which standards have been established. In no instance, however, can individuals perform official inspections unless they hold a valid license for that grain. As of September 30, 1987, there were 753 licensed inspectors employed by these agencies.

Procedures, Equipment Approval, and Monitoring. In addition to developing standards and providing inspection services, FGIS develops and publishes inspection procedures; evaluates and approves inspection equipment that must be used during inspection; monitors inspection accuracy of FGIS' employees and licensed inspectors; periodically tests sampling and inspection equipment for accuracy; provides appeal inspection; and responds to complaints regarding service. FGIS also audits its own activities to ensure that service is being provided on a nondiscriminatory basis and that no licensed individual has a conflict-of-interest.

ASCS, Warehouse Division, USDA

ASCS' Warehouse Division operates under the authority of the United States Warehouse Act (USWA). The USWA provides the Warehouse Division with authority for federally licensing warehouses. As of September 30, 1987, 1,757 warehouses had been licensed under the USWA.

This number does not necessarily represent the actual number of federally licensed warehouses since many of these licenses are issued to grain companies which have more than one grain handling facility in a particular area.

According to the USWA, all grain received or shipped from a federally licensed warehouse must be inspected according to grain standards established under the USGSA. In order to comply with these requirements, the grain must be inspected by a USWA inspector, FGIS inspector, or an FGIS licensed inspector.

Licensing Procedures. The Warehouse Division, ASCS, has developed an inspection and weighing system. According to Warehouse Division officials there were 10,902 licensed inspectors and weighers as of September 1987. The Warehouse Division does not distinguish between inspectors or weighers in their reporting so it is difficult to determine the actual number of USWA licensed inspectors.

Inspection services are carried out by individuals licensed to inspect grain under the USWA. Grain elevator employees, individuals employed by private, non-FGIS companies, or individuals licensed by FGIS may be licensed under the USWA. These individuals may be required to submit to examinations for grading proficiency, but according to Warehouse Division officials, proficiency examinations are not administered. The USWA relies on its application process regarding grading proficiency. The USWA requires that each applicant provide evidence of their grain grading competency and then certify to their own competency. Inspector's competency is only evaluated and verified by Warehouse Division examiners during on-site routine audits.

Procedures Development, Equipment, and Monitoring Activities. Other than the statutory requirement that grain be inspected according to grain standards established under the USGSA, no other directives have been developed or issued by the Warehouse Division regarding the inspection procedures to be followed. Licensed individuals must have inspection equipment for performing the tests required by the grain standards at their location. There is, however, no requirement regarding the type of inspection equipment to be used or a program for ensuring that the equipment is providing accurate results. Inspection accuracy is only monitored during on-site reviews by Warehouse Division examiners. According to Warehouse Division officials, examiners attempt to visit each licensed warehouse two times over a three year period.

Provisions have been made in the USWA for appeal inspections when an interested party disagrees with an inspection result. When an appeal inspection is requested, the buyer and seller must mutually agree upon a sample. The agreed upon sample is then forwarded to FGIS or an FGIS inspector for inspection.

Private Inspection

Inspection services using the grain standards established under the USGSA may be performed by grain company employees or by private companies not affiliated with FGIS. Grain received from farmers is very seldom graded by licensed inspectors, but by the employees of the elevator or processing firm. Since these are not official inspections, the factors graded, the discounts, and the break points for discounts are at the discretion of the individual buyer subject to competitive forces in the market. Equipment used by these firms is generally the same as that required by FGIS and the standards by which quality is determined follows the regulations promulgated under USGSA. Intercompany transfers and sales between firms may also be conducted without the benefit of official grades. Only export grain is required by law to carry an official USGSA grade designation.

The standards established under the USGSA are generally used as the basis for inspection by company employees inspecting grain. FGIS procedures may or may not be followed based on individual company policy. Equipment and inspection accuracy is not monitored unless the company has established an internal monitoring program. In many cases, inspectors compare their inspection results to results obtained by FGIS or an FGIS licensed inspector on the same grain in an effort to ensure accuracy. Either buyer or seller may request an official inspection by a licensed inspector if the results of the company employee is in question. However, neither party is required by law to abide by the inspection results. Individuals employed by grain companies or private companies cannot be licensed under the USGSA and may or may not be licensed under the USWA. There is no requirement that they be licensed under USWA unless the grain handling facility where they are employed is USWA licensed or has entered into a Grain Storage Agreement with ASCS.

Domestic Inspection. There is no single national policy regarding inspection requirements on domestic grain. Inspection is performed by one or more of the groups previously mentioned: FGIS, FGIS licensed inspectors, USWA licensed inspectors, private companies, or grain company inspectors. Official inspection is mandatory when a facility is licensed under USWA or has entered into a government storage agreement. Inspections may also be required as a condition of sale. In some instances inspections are used as a quality control function on grain moving between two grain handling facilities owned by a single company. In all instances, inspection requirements, along with the group performing the inspection, are determined by buyer and seller or the company that owns the grain.

There are three main factors that determine when inspection is required and who will perform it: Warehouse licensing by either the USWA or State; the Grain Trade Rules published by the National Grain and Feed Association; and the Uniform Grain Storage Agreement administered by ASCS. Each of these areas is discussed in the following paragraphs.

Warehouse Licensing. The USWA requires that all grain received and shipped from a federally licensed warehouse be inspected using the grain standards established under the USGSA. Inspection must be performed by either a USWA licensed inspector, FGIS, or an FGIS licensed inspector. Not all warehouses are federally licensed however. Some States have assumed responsibility for licensing warehouses within their jurisdiction. In these cases, each State defines inspection requirements that range from no requirement to inspection requirements similar to those contained in the USWA.

Grain Trade Rules. Whenever grain is traded under the National Grain and Feed Association trading rules, the sales contract specifies inspection requirements, whether settlement is based on origin or destination inspection, and who will perform the inspection. These rules make a clear distinction between "official inspection" and inspections performed by individuals other than FGIS or FGIS licensed inspectors.

Rule 4. B. in NGFDA rules defines "official inspection" as either Class A (white certificate), Class B (yellow certificate), or Class C (pink certificate). This classification is based on whether the sample was obtained by FGIS or an FGIS delegated or designated agency for Class A; and FGIS licensed warehousemen for Class B; or is submitted by an interested party for Class C.

There is no requirement that grain be officially inspected by FGIS or FGIS licensed inspectors. Each sales contract specifies whether settlement will be based on Class A, B, or C inspection or on inspection results provided by a group other than FGIS.

Rule 14 states that whenever sales are made from terminal or interior markets, inspections performed at the origin place of shipment, will prevail unless otherwise agreed to at the time of sale. In most instances, grain moving from country and terminal elevators into domestic or export channels is traded on origin grades. Since not all grain is inspected at the place of loading, many shipments are stopped somewhere during transit for inspection.

In order to comply with the origin grade for settlement clause, settlement is based on what is called "first official." This means that the first "official inspection" will be used for settlement. The major exception to this rule is grain moving into the Pacific Northwest. In the Pacific Northwest it is market policy to settle on destination grades even though the grain may have been previously inspected at origin.

United States Grain Storage Agreement. This is an agreement between the Commodity Credit Corporation (CCC), ASCS, and an individual warehouse for storing CCC owned grain. According to ASCS officials, approximately 9,200 facilities had entered into grain storage agreements in 1987. There is no requirement that a warehouse entering into a grain storage agreement be federally licensed under USWA. The warehouse already complies with the requirement contained in the grain storage agreement before grain can be stored.

Unless otherwise directed by CCC, grain moving into and out of warehouses covered by the grain storage agreement must be inspected. The agreement makes a distinction between truck and railcar movements. For inbound grain delivered by truck from a farmer, inspection is required and may be obtained from either FGIS, FGIS licensed inspectors or by grain elevator employees licensed under USWA. The decision is strictly up to the two parties involved.

On CCC owned grain being loaded out for shipment by truck, samples taken by grain elevator employees at destination are submitted to FGIS or FGIS licensed inspectors for inspection. CCC grain being loaded out for shipment in railcars is normally inspected by FGIS or FGIS licensed inspectors. There are instances where CCC has waived this requirement on railcars when FGIS or FGIS licensed inspectors are not available. In these instances, inspection was performed by individuals licensed under USWA. Inspection on railcars may be obtained either at origin, destination, or both.

Illustration of Grain Inspection in Practice

In order to better understand the inspection requirements placed on any one grain handling facility, the following example is provided. If a particular grain handling facility holds a USWA warehouse license and handles grain owned by another grain company as well as its own grain and has entered into an agreement with ASCS to store CCC owned grain, inspection on grain moving into and out of the facility will generally be as follows:

Company Owned Grain. Grain being bought from a farmer will generally be inspected upon receipt by a grain company employee. Grain being shipped between facilities owned by the company may or may not be inspected. If it is inspected, inspection can be performed by company employees, FGIS inspectors, FGIS licensed inspectors, or other private concerns. Grain being sold to another company will probably be traded under the National Grain and Feed Association trading rules and fall under their inspection requirements.

Handling Another Grain Company's Grain. Grain being handled for another grain company moving into and out of the facility falls under the USWA and must be inspected by either a USWA licensed inspector, FGIS, or an FGIS licensed inspector as per agreement between both parties.

CCC Owned Grain. CCC owned grain is inspected according to the provisions outlined in the grain storage agreement.

Domestic Inspection Volume

No data is available on the total number of inspections performed on domestic grain. The only inspection volume data available is FGIS' inspection volume reports.

The following tables depict the number of truck, railcar, and barge loadings as compared to FGIS inspection volume for these carriers. These figures provide some indication as to the total number of carriers inspected by FGIS and FGIS licensed inspectors.

FGIS inspection volume covers the identical periods for each type of carrier. FGIS inspection volume figures do not include inspections performed on samples submitted by grain elevator management or reinspection and appeal inspection.

FGIS inspection volume figures over-report the actual number of carriers shipped during the periods being reported. This over statement results from the fact that any one railcar or barge may be inspected more than once during a particular shipment. This point is apparent when reviewing the barge data which indicates that the total number of inspections exceeds the number loaded. According to grain industry officials, anywhere from 15 to 30 percent of the railcars and barges shipped are inspected more than once by FGIS or FGIS licensed inspectors.

TOTAL NUMBER OF CARRIERS INSPECTED BY FGIS

TRANSPORTATION MODE	TOTAL NUMBER LOADED	TOTAL NUMBER INSPECTED
Railcars 1/	1,365,471	1,015,427
Barges 2/	37,550	46,318
Trucks 3/	Unknown	439,399

1/ The railcar figure represents the number of loadings on Class 1, regional, and short line railroads for the period January - December, 1986 and includes 100,000 loadings on regional and short line railroads.

2/ Barge loadings cover the period July 1984 - June 1985. During this time, grain industry officials indicated that all barges were being inspected by FGIS. Since this time, several grain companies have elected to ship intra company shipments without FGIS inspection.

3/ The majority of the trucks inspected by FGIS were inspected at export or process elevators and not at country elevators on farmer delivered grain.

Export Inspection

The USGSA requires that all grain being exported be inspected by FGIS inspectors or an FGIS delegated State agency. The only exception to this rule is grain moving into Canada and Mexico by land carrier and for small exporters who ship less than 15,000 metric tons in a given year. In 1987, only 37 such exceptions for small exporters were requested and granted.

Even though FGIS is required to inspect all grain being exported, overseas buyers often request private companies located here in the United States to represent their interests and inspect the grain as it is being loaded. Inspections performed by private companies can include inspection for grade as defined by grain standards established under the USGSA or for factors not covered by these standards such as falling number in wheat or oil and protein in soybeans. In cases where private companies perform inspection using the grain standards, two groups issue inspection certificates: FGIS and the private company.

Samples obtained by private companies are often submitted to FGIS for analysis and grade. When samples are submitted to FGIS, FGIS' results are used as the basis for the private company's certification. In other instances, private company inspectors actually perform the inspection. Settlement in most instances is based on the inspection results provided by FGIS or an FGIS delegated State agency. In rare cases, such as corn shipments to Portugal, settlement has been based on the private inspectors results or destination grades.

Setting Grades and Standards

The grades and grade factors are established by FGIS under the authority of Part 800.4 of USGSA. In the case of corn and wheat, these factors were selected in the early 1900's. Soybean grades were established in 1922 as voluntary and brought under the USGSA by a congressional amendment in 1941. There were no changes in the number of factors included until the removal of moisture from wheat in 1934 and from corn and soybeans in 1985. However, grade limits and definitions for the factors were changed frequently during the ensuing years.

The procedures for changing grades are clearly specified in the USGSA. Part 800.4 regulations of the USGSA outlines procedures for establishing regulations, standards, and official criteria. This section states that "... notice of proposed rulemaking to establish, amend, or revoke regulations, standards, or official criteria will be published in accordance with the provisions of the Administrative Procedure Act (5 U.S.C. 551 et seq.)." The Federal Register is the vehicle used for publishing proposals under the administrative Procedures Act.

The process of establishing, amending, or revoking policies residing in regulations can take many forms using three basic types of publications: Notice of Intent, Proposed Rulemaking and Final Rulemaking.

A Notice of Intent published in the Federal Register usually begins the rulemaking process, but is not required. This document is used to notify the public that the policies contained in a particular regulation are being reviewed. It requests comments on the adequacy of the existing policies, but can be used to solicit suggestions on how to handle specific issues. It is not normally used to establish new policy and FGIS has used it mainly to announce the beginning of each 5 year review period of existing regulations.

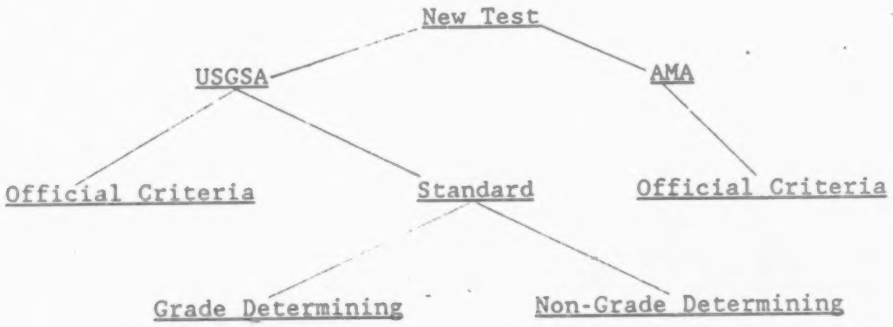
Proposed rulemaking is required and involves publishing specific proposed changes to existing regulations or proposed new policies that will be contained in regulations in the Federal Register. Information received from a Notice of Intent, if used, along with any other available information is used to formulate proposed or new regulations. This document solicits comments on the specific proposals and provides a time frame, usually 60-90 days, for comments. Once all comments have been received, they are reviewed and a decision is made on the proposal. If the comments received from the proposal indicate that changes should not be implemented as proposed but could be implemented if changed, a second proposal is then published with the revised changes.

Final rulemaking closes out the process. If the proposed changes are being adopted, this document announces the adoption of the proposed change. The final rulemaking document is also used if it is determined that proposed changes will not be adopted based on comments received on the proposal. In the final rulemaking document, a date for implementation is provided. In the case of establishing new, amended, or revoked Part 810 regulations, the USGSA, Section 4 (a), requires a 1 year waiting period. This means-that policies contained in the final rule will become effective 1 year from the date of publication in the

Federal Register. Part 800 regulations, which includes actions on official criteria, can be implemented immediately upon publication or can be delayed for a period of time, 30-90 days, at FGIS' discretion.

The Federal Register is also used to announce public hearings. Public hearings can be held any time prior to final rulemaking in order to gather information or solicit comments on specific changes or the need for change.

Changing and revising the grade factors require an understanding of the alternatives for implementing the introduction of a new test or quality factor. There are two authorities involved (USGSA and the Agricultural Marketing Act) with three options under USGSA (Figure 1).



Official criteria are provided only on request of buyer or seller. Factors in the standards are required to be reported with every official grade. Non grade determining factors are shown on the certificate but do not have maximums or minimums associated with the numerical grades. Grade determining factors establish the numerical grade according to the [illegible] factor approach. The four categories are illustrated below (Table 1).

Table 1. Examples of quality measures under USGSA and AMA.

AUTHORITY	EXAMPLE FACTORS
USGSA	
Grade Determining Standards:	Foreign material Damage Test Weight
Non-Grade Standards:	Moisture
Official Criteria:	Protein in Wheat
AMA	
Official Criteria:	Aflatoxin Falling Number Pesticide Residue (EDB)

In summary, FGIS operates under two pieces of legislation: USGSA and AMA. Regulations and standards have been promulgated under each statute. Regulations implement the overall programs established by each statute. The standards only define and outline the specific factors and establish grades. Both statutes provide for testing under "other criteria".

The Food and Drug Administration (FDA) also has responsibility over grain quality issues related to health and safety. For example, pesticide residues, aflatoxin and adulteration. It was an FDA ruling that the addition of water to grain to increase its weight or value was adulteration and subject to prosecution. The separation of responsibilities between FGIS and FDA is somewhat vague in principle. For example, dust in grain is a health and safety issue but it is under

FGIS not FDA. While some might argue that all aspects of grain should be under FGIS in order to concentrate responsibility under one agency and on the grounds of efficiency, the micro analysis for residues is dramatically different from the macro analysis of test weight, for example. On the grounds of measurement technology and analytical methods there seems to be justification for maintaining the current separation of responsibilities.

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Authority for Grading and Inspection

Section 3 A of the USGSA provided the basis for establishing FGIS. According to this section, the FGIS Administrator is responsible for carrying out all provisions contained in the USGSA. The Administrator can issue policies, guidelines, and regulations for FGIS to use in carrying out these provisions.

Section 4 of the USGSA defines the grains covered, establishes the requirement for standards to be developed for these grains, and outlines the rule making process used to promulgate the standards given in 7 CFR, Part 810. Section 7 (a) of the USGSA requires that the Administrator provide inspection on export grain as required by Section 5. Section 7 (b) authorizes the Administrator to provide inspection of domestic grain upon request. This section also provides the Administrator with the authority to provide tests not specifically covered in the standards that are requested by the industry. In other words, there is no requirement that a new test be included under a standard.

FGIS uses two documents that are subject to public or legislative input under the USGSA: 7 CFR Part 800 regulations and 7 CFR Part 810 regulations. The USGSA establishes the basic framework for standard development and a national "third party" inspection service administered by FGIS. The Part 800 regulations define how this service will be provided including the application of the standards. The Part 810 regulations deal specifically with the standards themselves.

A review of the Part 810 regulations will identify that these regulations do not describe how they will be implemented. They only define factors as they relate to the standard and provide a framework for assigning grades. Factors defined in the standards may or may not be grade determining. Moisture is a good example of a factor that is not grade determining. The standards as they are presently written define factors and equipment used to perform tests, e.g. sieve sizes; establish the basis for performing the test, e.g. after the removal of foreign material; the grade structure, e.g. 1,2,3, and Sample grade; the factor limits, e.g., 3% BCFM for No. 2 corn; how the factor will be reported, e.g. nearest tenth percent; and special grades. Specific procedures for implementing the standards, such as portion size, when factors must be analyzed, and interpretations are found in the Part 800 regulations and directives issued under this authority.

A further review of Part 810, Subpart B, Barley, and L, Wheat, will identify that protein is not mentioned. The test for protein in each of these grains has been established via the Federal Register under the authority of Section 7 (b): other criteria. The definition for official criteria can be found in Part 800.0 (61).

Prior to being offered by FGIS, protein was subjected to the full rule making process, i.e., a proposal soliciting comments and final rule making. It is important to note for future strategy that tests established under Section 7 (b) are not subjected to the 1 year waiting requirement for implementing standards and are not subjected to the mandatory export requirements of Section 7 (a). In the case of protein, each test was implemented at the beginning of a crop year.

[illegible] previously, Part 810 regulations do not provide information regarding how these standards will be applied or when factors must be analyzed. Part 800, Section 800.162 (a), (b), and (c) provides the regulatory requirements for determining and reporting inspection results. In general, Section 800.162 [illegible] required that factor results be reported for: test weight and moisture on each inspection; any factor result that was determined during the course of the inspection; any factor result that would cause the grain to grade other than No. 1; and any factor result requested by the applicant for inspection. Section 800.162 (b) includes the recent requirement for reporting broken kernels and foreign material separately. The changes mandated by the 1986 Grain Quality Improvement Act regarding the reintroduction of dust, blending, and reporting broken kernels, were implemented via the Part 800 regulations and not the standards. Section 800.162 (c) requires that all factors defined in the standards be determined on export shipments.

What Section 800.162 does in effect is say that on domestic inspections an inspector is only required to determine test weight and moisture and factors that in his/her opinion will grade the grain lower than No. 1. In the case of grain being received from a farmer (which is usually No. 1), inspectors are not required to determine anything other than test weight and moisture unless the applicant for inspection requests specific factor information. For wheat and barley, protein must be requested before inspectors can make this determination, because it is designated as official criteria.

To complicate matters further, there is no requirement that a grade must be assigned for each inspection. Section 800.75 (b) (2) allows applicants for inspection to request inspection for only specific factors. This is called a "Factor Only" inspection. In many areas of the country, "Factor Only" inspections are performed on grain being delivered to an elevator by a farmer or to a processing plant. In these instances a grade is not assigned.

An example of the extent to which these policies have gone is demonstrated by the fact that CCC has sent letters to all FGIS and FGIS delegated and designated agencies specifically requesting that all factors be determined and a grade be assigned on CCC owned grain. A review of inspection certificates covering domestic inspections reveals a range of factors being reported for each grain regardless of whether or not a grade is assigned. The information requested ranges from only test weight and moisture to all factors depending on the policy of the inspection agency and requests by individual grain companies.

One other point to consider is that according to Section 3 A of the USGSA, the FGIS administrator may be delegated authority by the Secretary to perform inspection under other statutes administered by USDA. A delegation of authority from the Secretary has been provided in this area. Part 800.2 regulations describe the Administrator's responsibilities in carrying out the delegated functions assigned under the Agricultural Marketing Act of 1946 (AMA). In effect, FGIS operates under two separate statutes for inspecting grain and can pick and choose under which one a new test is to be performed.

FGIS has published regulations under 7 CFR Part 68 implementing the AMA programs delegated to them. This delegation in effect allows FGIS to perform any test on grain or grain related products requested. Examples of grain related tests currently being performed under AMA are aflatoxin, pesticide residue (EDB) and falling number.

The AMA regulations [illegible] inspection under this authority are very similar to the Part 800 regulations of USGSA. The main differences are that only FGIS can perform the service and no mandatory export inspection requirement exists. Most of FGIS' inspections performed under this authority are on graded commodities such as rice, peas, beans, lentils, and processed commodities such as flour. As background, FGIS provided protein testing and quality information on sunflower seed under this authority for several years before these factors were moved under USGSA.